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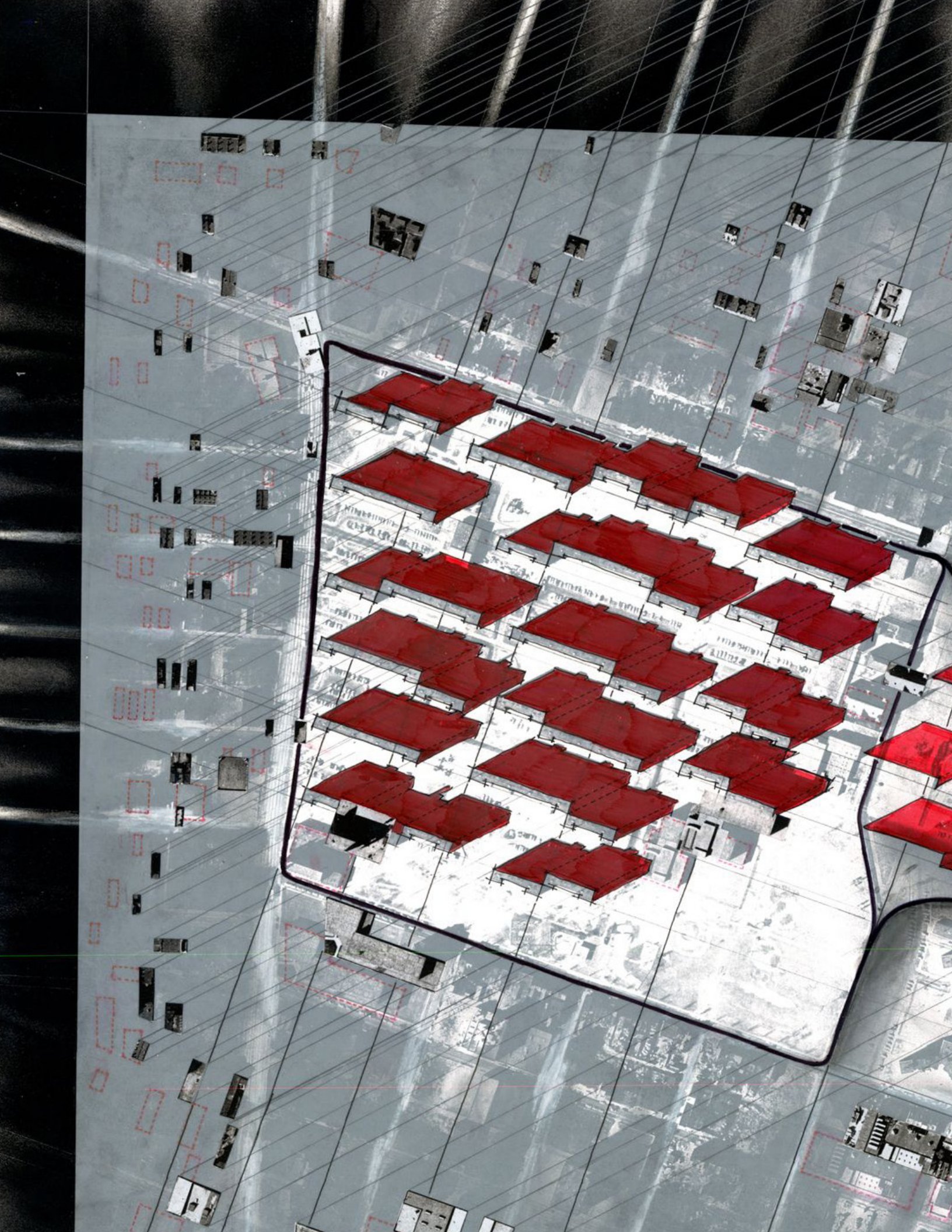
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Drawing Out Surface

By Brian M. Kelly, RA, Assistant Professor
University of Nebraska-Lincoln, Architecture



translation: **noun 1. the changing from one position, form, medium, or condition to another**

THE GAP MECHANISM

Translation is a mechanism that links two or more entities together. Difference, which is established in the definition referencing “from one - to another”, is where translation operates and establishes the existence of a gap. This gap is where the transfer of content is conveyed. In the context of language translation, existence in one medium assumes existence in another. Conversely, visual translations in media such as art and film see the potential of content alteration and personalization for each viewer as opportunistic. Even with the transmission of sound, waves pass through the medium of air, which, depending on atmospheric conditions, can alter sound reception. With regards to architectural representation, Robin Evans states “the assumption that there is a uniform space through which meaning may glide without modulation is more than just a naïve delusion.”¹ When consuming representation, a projective act is deployed between the viewer and the viewed. This projection of content and subsequent reading is neither objective nor without the influences of culture.

Since translation is not specific to architecture or its representation, we might better understand the fertile ground of what I refer to as the ‘gap mechanism’ through locating it within other communicatory media. For example, movement in film is perceived through multiple frames played in rapid succession. As a necessary corollary of the multiple frames, the tangible gap between two frames is the place where motion is perceived through difference. This occurs through slight shifts in object and form placement, as well as viewpoint, allowing the human eye to perceive difference in real time which is equated to movement. The gap between frames, measured in fractions of a second, cannot be perceived by the naked eye and often goes unnoticed as an aggregation of millions of still frames in a standard length film.

Written text and its legibility are also dependent on the gap in its physical state. Using the Gestalt principle of proximity, groups of adjacent letters distinguishes the beginning and end of a word by locating breaks on both sides of the grouping. Since the human eye does not read a word in a linear fashion from beginning to end but rather through grouping of letters, the aggregation allows recognition and in turn the reader to assign meaning. Although the gap exists between words and is essential in the communication of content, the focus is on adjacent words.

PERCEIVED OBJECT
"DEEP SPACE" / 3D

PERCEPTUAL
OSCILLATION

SURFACE TEXT
"FLAT SPACE" / 2D





[left] Figure 1. “Deep Space / Flat Space” diagram by author.
Painting by Rene Magritte

“Projection, in particular, implies an active, transitive condition. By the translation of measure and proportion across scale, architectural projections work to effect transformations of reality at a distance from the author. Projections are the architect’s means to negotiate the gap between ideas and material [...]”²

PROJECTION AND SURFACE

The previous two examples, film and text, use the gap as a physical entity in the communication where content is established through bridging two or more things of difference being movement and concept, respectively. This gap mechanism also exists in an intangible form and is the place where, among others, architects capitalize on the potential incongruence of content being translated. The gap mechanism in the context of architectural representation is most often referred to as projection, and its surface becomes the place of recording.

Kester Rattenbury, in the introduction to *This is Not Architecture*³, refers to the 1929 painting by Rene Magritte titled “This is not a pipe,” and establishes an important distinction with significant relevance to the practice of architecture, specifically the techniques used to communicate within the profession. The painting, depicting a single smoking pipe filling a large portion of the canvas with script writing below reading “Ceci n’est pas une pipe,” lays bare the situation that the painting is not a pipe, but rather an image of a pipe. Magritte said of the painting:

“The famous pipe. How people reproached me for it! And yet, could you stuff my pipe? No, it’s just a representation, is it not? So if I had written on my picture ‘This is a pipe,’ I’d have been lying.”⁴

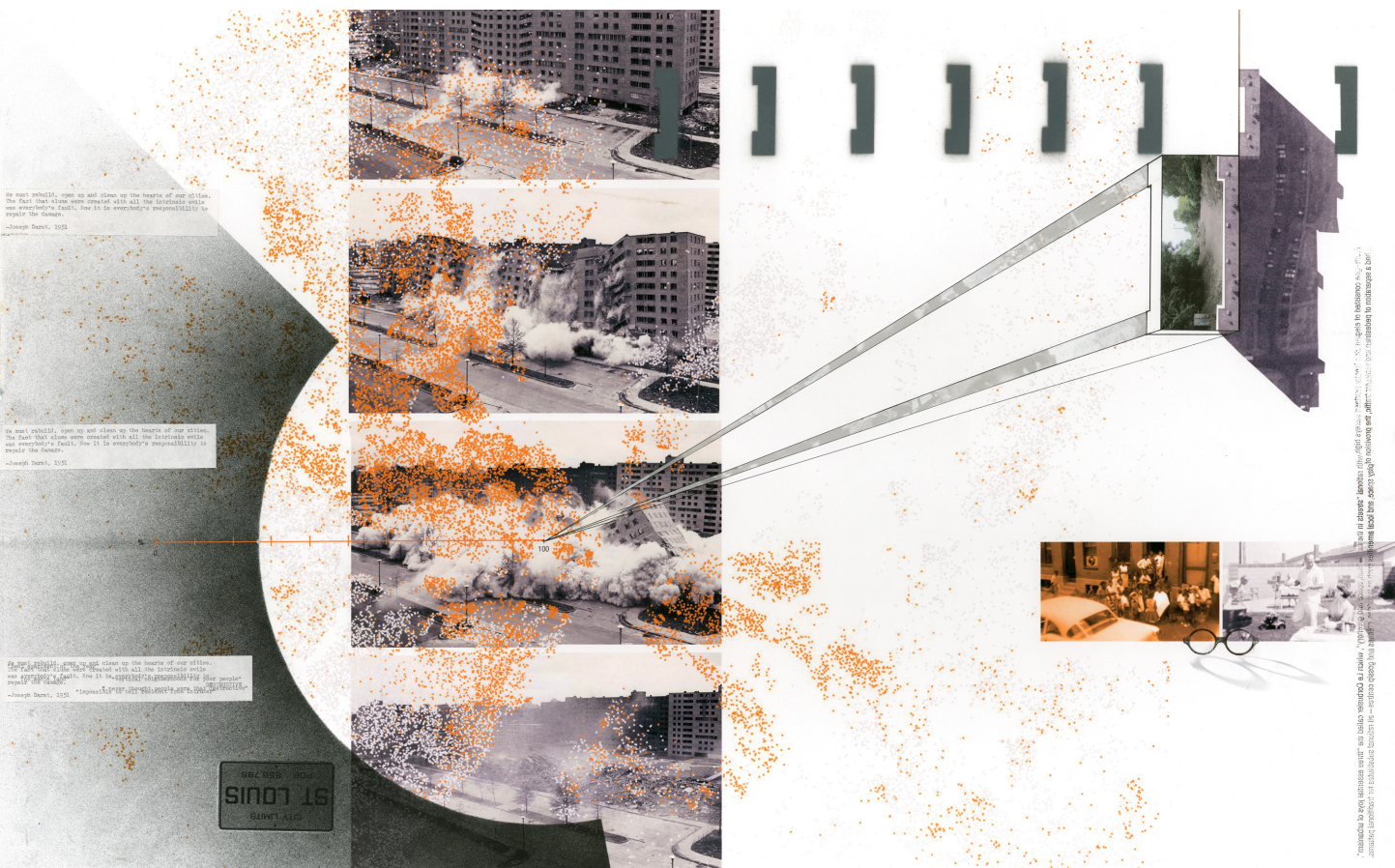
What’s interesting is that it was not necessary for Magritte to state anything. Painters past and present have predominantly not felt the need to identify for viewers the painting’s subject; rather they allow the viewer to draw a conclusion. Magritte’s assertion intended to alert the viewer that they were not looking at the real object, and thus to delay the projective connection between the viewer and the represented (the pipe). (See Figure 1)

The use of this text in Magritte's painting ignited various discussions regarding the meaning of the text, as well as the cyclical, referential engagement that ensues between the viewer and viewed. Michel Foucault discusses this painting and its linguistic twists at length through his book *This Is Not a Pipe*.⁵ His discussions point to the existence of at least two versions of the painting, the first of which shows the pipe "juxtaposed in a neutral, limitless, unspecified space"⁶ and Magritte's alteration of the composition in *Les Deux Mysteres* which places the original painting on an easel within a space of little definition outside of a wide slatted wood floor. Above the easel is another, much larger pipe floating placeless in the space above the original painting. Foucault's discussion of the original exhaustively analyzes the back and forth exchanges of the word "this" and the representation of the pipe. "This", which refers to the pipe in the painting, is denoting the existence of something negated by the remainder of the text, stating it "is not." This establishes a cyclical loop catching the viewer in a back and forth visual game of references continually jumping over a translational gap.

While Foucault's points are valid, I would additionally argue that with the first painting, and more pointedly in the transition to the latter, Magritte has brought an awareness of the existence of the surface. He brought the gaze of the viewer back to the surface of the canvas, rather than unknowingly through it (as was the case in traditional landscape painting). In the first painting, the pipe is rendered three-dimensional with tonal variation and light reflection, and is set upon a flat background containing the text. This background helps to objectify the pipe establishing, in conjunction with the text, a parallax. The pipe appears to be a pipe, but yet is not. The viewer continually moves from perception of an object (the pipe) to the surface of the painting (the text). The latter version furthers this discussion through the clarification of the first being a flat painting sitting now on an easel, and conceptually supported with the existence of another pipe floating placeless above. Magritte denies the viewer an opportunity to place this second pipe within the room he has provided by giving no clues as to its placement. This play, I would argue, is again another suggestion for the viewer to oscillate between perspectival space and flat space in much the same manner as with architectural representation.

Architect Perry Kulper champions a continual oscillation from the working surface to the space "behind, beneath, and though the space of the drawing"⁷ suggesting an alternative position for its projective potential. His drawings for projects such as David's Island Competition explore this condition through hybrid techniques, which include "indexical sets, notation, diagrammatic assemblies, material indications, language and other generative marks."⁸ The mixing of these techniques is the location where the drawing's potential to gain its own logic and communicatory ability is mined. Projection occurs between the author and his/her marks, as well as between the various tactical systems deployed

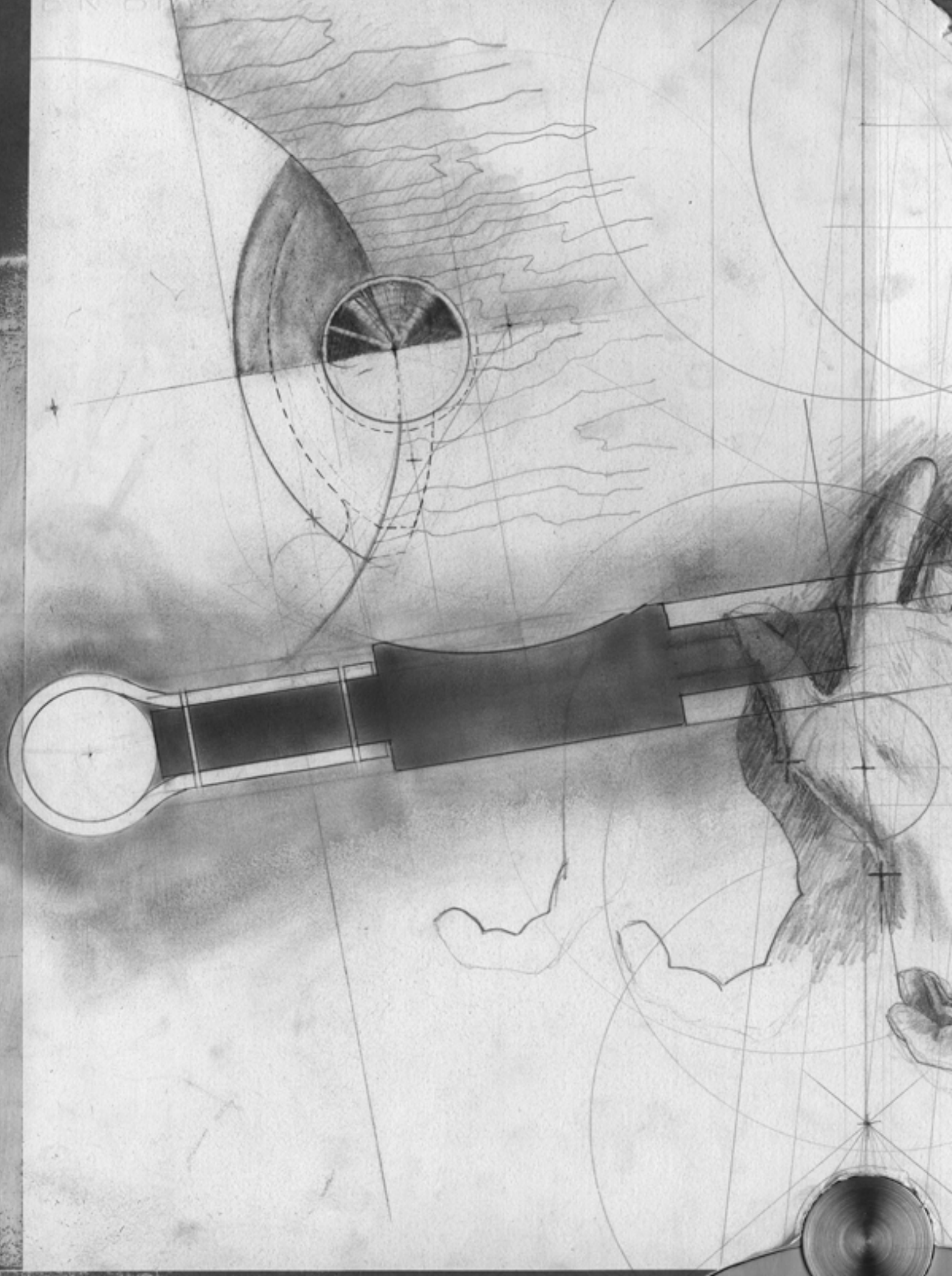
"The famous pipe. How people reproached me for it! And yet, could you stuff my pipe? No, it's just a representation, is it not? So if I had written on my picture 'This is a pipe,' I'd have been lying."



[above] Drawing by Taylor Nielsen.

within the drawing. Robin Evans addresses this persistence of the gap stating, “What connects thinking to imagination, imagination to drawing, drawing to building, and buildings to our eyes, is projection in one guise or another.”⁹ This act of projection suggests the potential of a catalytic condition existent in this oscillation between technique and perception and its documentation on surface.

The presence of the surface manifest through notational systems and indexical marks, primarily in the analog realm, works in much the same way as Magritte’s text - offering the viewer a simultaneous awareness of the surface of the drawing and the space within the drawing. The systems of notation used by the designer through the process are often used to identify, refer, and defer within the decision-making. The drawing surface becomes a storehouse, documenting the acts of design and projection, giving clues of how to read the content of the representation. Additionally, the adventitious marks made from physical interaction with the surface become traces of the act. This together manifests ownership and authorship to drawing, and has historically documented the investment of the designer into what Le Corbusier calls “the patient search.”¹⁰



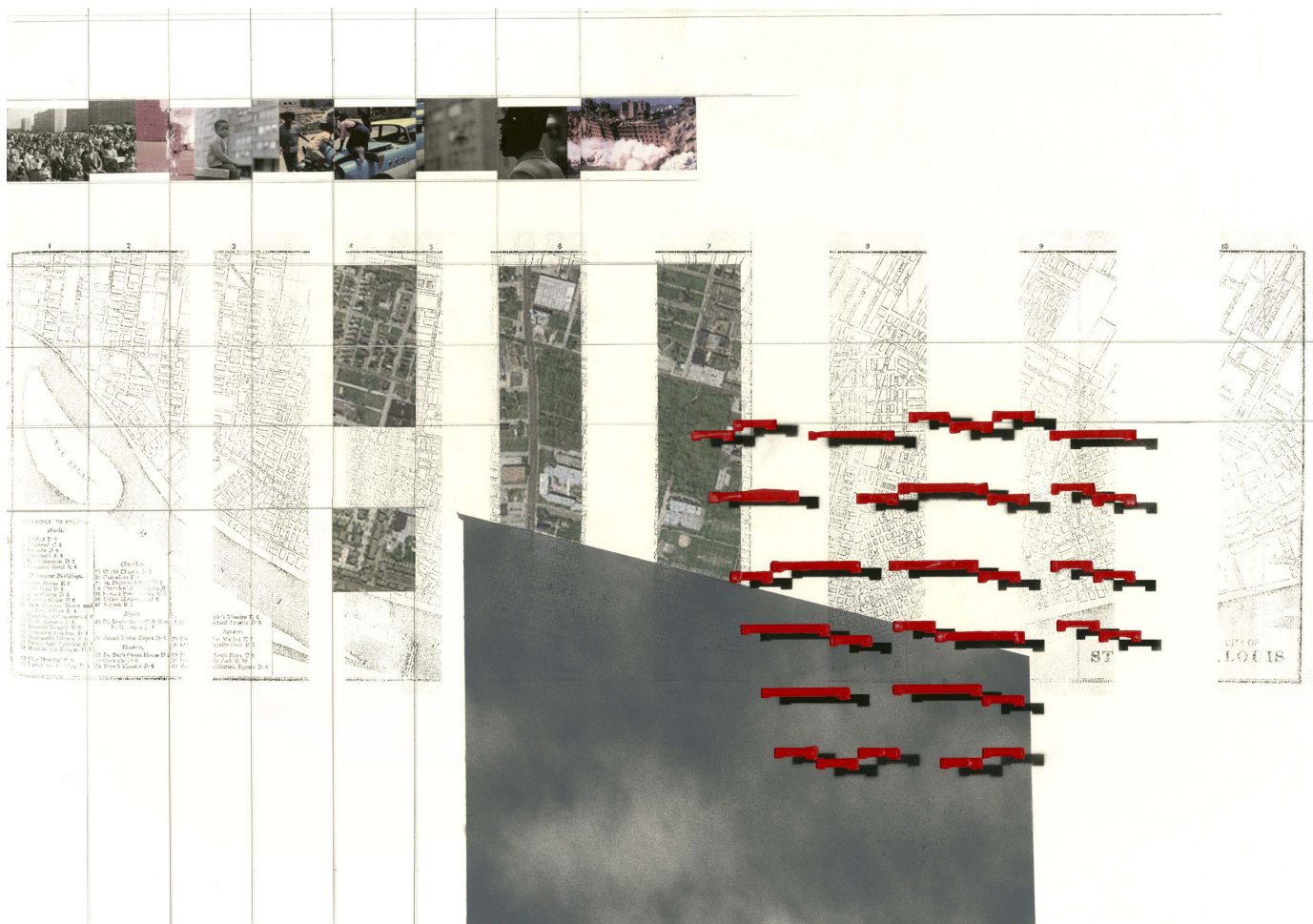


THE DIGITAL 'SURFACE'

Architectural drawing has gone through significant changes in the last 15 years, and this text so far has disregarded the existence and proliferation of the digital tools at the disposal of the designer today. For the most part, drawing today does not require physical interaction with a drawing surface. Rather, designers use input devices such as mice and tablets to manipulate pixels in digital space. Although technology, like tablets for example, might employ a stylus activated through similar movements as analog drawing, the direct feedback of move to mark is delayed or displaced. Additionally, the input of these movements is limited to the tip of the stylus, never allowing acts like the swipe of the hand to violate the surface. While the use of a digital interface incorporates the physical flatness of a display monitor, this surface might be compared to the surface in traditional landscape painting technique - hiding in front of our face.

If the occupation of a working surface has for the most part disappeared in a contemporary practice setting, this begs the question of how important is the physical trace within the design process. Is it a vestige of outdated techniques not as valid in today's design culture? A better way to consider this question might not be to think in terms of a binary (yes/no), but rather to embrace a both/and condition. This would consider the ways in which new input devices might suppress the desire to view the drawing as an exclusive place of exploration. This might also allow new interpretations on traditional media infatuations such as palimpsest, creating new digital versions embracing the essence of the attraction. This essence in the case of palimpsest is the existence of a permanent register and the coexistence of temporal content pertinent to the projection of formal and material assemblies. The surface records the thoughts, musings, and increased comprehension of the designer.

While the forms and the ways in which we communicate them have evolved, many contemporary tools have their roots in historical techniques. For example, the Boolean operation in digital modeling is essentially a retooling of Monge's descriptive geometry from the 18th century. Historical precedent might suggest that techniques which catalyzed the drawing's surface as a place of discovery could be reinvented and reconceived for a contemporary practice context. The speculative potential of recording the movement of projection through a drawing's surface has been all but lost in a



[previous page] *Drawing by Jeff Hammerquist.*
 [above] *Drawing by Ricky Hautman.*

world of digital modeling where the gaze remains in deep space. Interactive touch technology might again invigorate the drawing's surface as the lines of projection move between flat and deep space, manifesting the operations of the gap mechanism. This might also reactivate the potential of the surface of the 'drawing' to catalyze its "speculative, imaginative, and latent capacities."¹¹ Whether discussed in the context of painting or architecture, the act of projection and the surface in which it is recorded retains the opportunity to be an active, volatile, and speculative repository of the design process.

¹ Robin Evans, *Translations from Drawing to Building and Other Essays*. London: AA Publications, 2005), 154.

² Stan Allen, *Practice: Architecture, Representation, Technique*. (New York: Routledge, 2009), 2.

³ Kester Rattenbury, *This is not Architecture*. (New York: Routledge, 2002), p. xxi

⁴ Harry Torczyner, *Magritte: Ideas and Images*. (New York: Harry N. Abrams, Inc., 1979), 71.

⁵ Foucault, Michel, *This is not a Pipe*. (Berkley: University of California Press, 1983)

⁶ Ibid. p. 15.

⁷ Perry Kulper, "Representing Beyond the Surface," *arcCA: Architecture California* 05.3 (2005): 19.

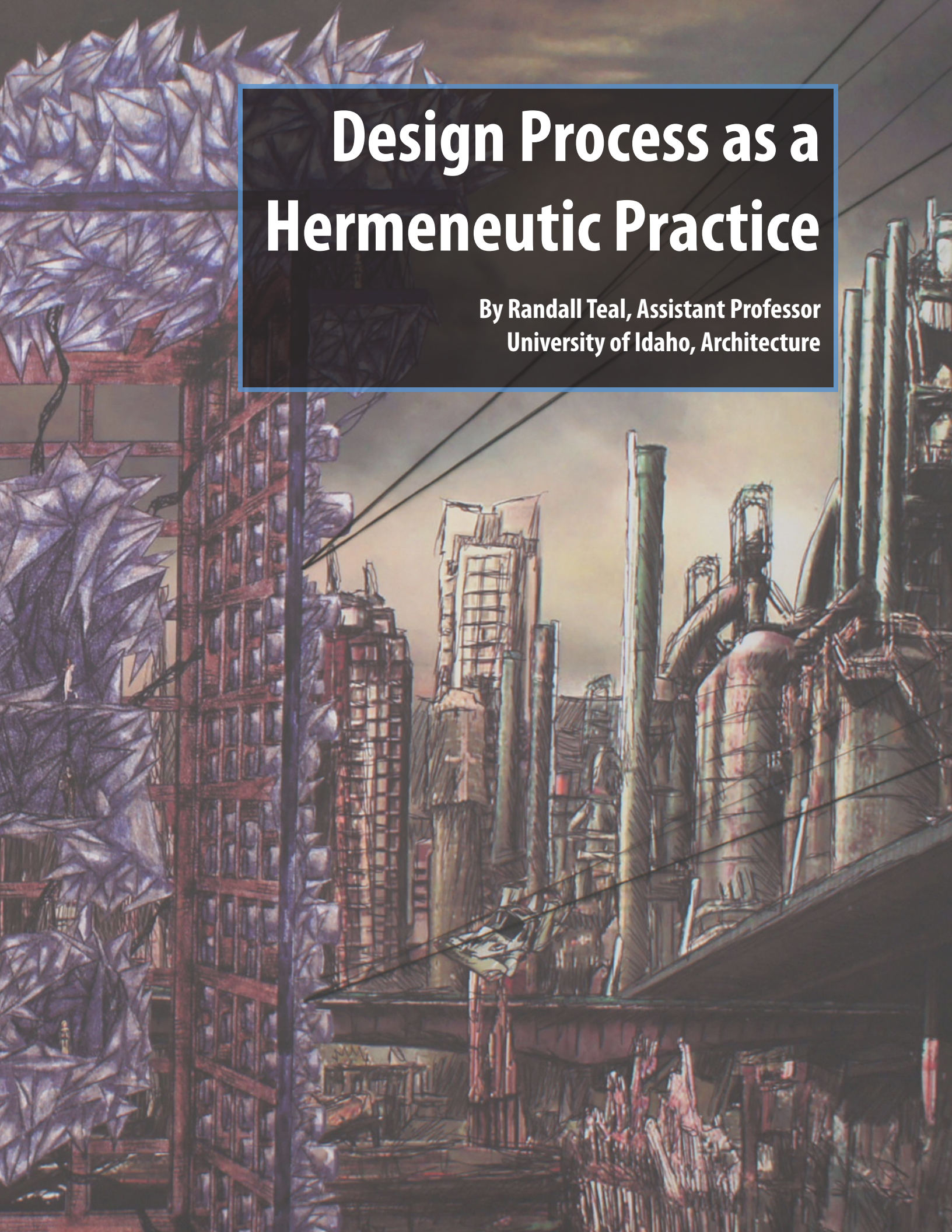
⁸ Ibid. p. 18.

⁹ Robin Evans, *The Projective Cast*. (Cambridge: The MIT Press, 2000), xxxi.

¹⁰ Le Corbusier, *Creation is a Patient Search*. (Praeger, 1960)

¹¹ Perry Kulper, "Representing Beyond the Surface," *arcCA: Architecture California* 05.3 (2005): 19.





Design Process as a Hermeneutic Practice

By Randall Teal, Assistant Professor
University of Idaho, Architecture

The world is not a solid continent of facts sprinkled by a few lakes of uncertainties, but a vast ocean of uncertainties speckled by a few islands of calibrated and stabilized forms.¹ Bruno Latour

A balanced and rigorous design process is basic to the success of any aspiring designer. However, a too-rigid framework for this process can mask a critical deficiency—an inability to cope with uncertainty. This is a supreme deficiency, because design fundamentally concerns working with the unknown of new situations and unfamiliar circumstances. Ultimately, the failure to thrive upon such uncertainty will leave behind designs beholden to atomistic fixes and the re-application of familiar means to unfamiliar problems.² Here design fails to reach its richest possible ends.

Hans-Georg Gadamer critiqued a similar deficiency in the hermeneutic tradition. Gadamer believed that despite its original concern with scriptural interpretation, hermeneutics had been appropriated by modern science as an explanatory technique, the sole goal of which was to achieve certainty in understanding. This new and troublesome application of hermeneutics aimed to eliminate prejudice by bolstering the soundness of method. Gadamer argued that rather than improving understanding through a methodological construct, “understanding must be conceived as a part of the event in which meaning occurs.”³ In other words, events are temporal and situational and must be grasped with a similar dynamism. Thus Gadamer’s hermeneutics begin with a basic premise: our understanding is more dependent on our “prejudices” than our rational judgments. In this provocation, Gadamer argues that hermeneutics become trivial if “restricted to a technique for avoiding misunderstandings.”⁴ In response to such a deficiency, he sought to reconnect “the objective world of technology...with those fundamental orders of being that are neither arbitrary nor manipulable by us, but rather simply demand our respect.”⁵

Architecture is certainly a realm subject to Gadamer’s critique of scientific hermeneutics in that it is an easy mark for the simple instrumentalism of technological thinking – despite the fact that the material and experiential dimensions of architecture show it to be clearly underpinned by many fundamental orders that are “neither arbitrary nor manipulable by us.”⁶ In this article I argue that Gadamer’s critique of method and the hermeneutic practice he proposes are helpful for developing a balanced and rigorous design process—one that is engaged and activated by orders “neither arbitrary nor manipulable by us.” Such a process begins by treating ambiguity and uncertainty as fundamental to the activity of design and learning how to glean understandings through uncertainty instead of trying to eliminate it.

THE PREJUDICE AGAINST PREJUDICE

Gadamer explained that there is a difference between developing a system (method) for understanding, and developing habits and capacities (practice) for response; and he argued that the Enlightenment's emphasis on "method" tended to obfuscate the value of "practice."⁷

In developing and advocating his hermeneutics, Gadamer was interested in promoting the qualitatively different understanding that arises out of practice. The value of practice, Gadamer thought, is that it is informed by a deeply embedded awareness born from custom, tradition, and the temporal nature of our existence. Unfortunately, it is the very embeddedness of practice—its situatedness and contingency—that made it a target for suspicion. During the Enlightenment this suspicion led to "raising 'critical rationality' to the status of an absolute measure of truth," which, according to Gadamer, resulted in science's regard of hermeneutics as mere "theological obscurantism."⁸ In short, the legacy of the Enlightenment and its desires for certainty undermined the validity of knowledge gleaned through practice by suggesting that practice's very temporality marked it as unscientific, biased, and therefore unsound.

In protest, Gadamer turned the table on prejudice, stating that "the fundamental prejudice of the Enlightenment is the prejudice against prejudice itself, which denies the tradition its power."⁹ Here, Gadamer is pointing out that by undermining practice, method obliterates the ways in which custom and tradition contribute to our knowledge. Most importantly, he sees that the same techniques used by method to eliminate error—i.e., objectivity, quantification, isolation of facts, explicit definitions, categorization, abolition of variables, linear causality—created procedures that also excluded the multiplicity of a lived world. Now, it is important to note that this is not an argument *against* science; rather, it is one that is *for* practice. As such, it is a call to accept two different modes of understanding, treating them both as valid but different, and therefore appropriate for different purposes. Or as Albert Einstein wrote, "when the laws of mathematics refer to reality they are not certain. And when they are certain, they do not refer to reality."¹⁰ In short, method creates a limited point of view that it cannot cope with influences, relationships, indicators, and ephemera—in other words, all the specifics of particular living situations. For architecture, this point is critical because as a profession that is rooted in engaging, editing and activating living situations, method is not an aid, it is an obstruction. Rather than relying on method, architects must learn to embrace architectural practice in a most radically literal way; and this can best occur when practice becomes prejudiced.

Typically, the notion of prejudice is synonymous with being shortsighted and unresponsive. Why then does Gadamer suggest that our prejudice is more important than reasoned judgments in our relation to the world? The answer to this

question begins with his understanding of the word. In “prejudice” Gadamer wants one to hear a pre-Enlightenment conception of the term, one that implies that there is never an “unobstructed view of all the facts.”¹¹ That is to say, prejudice indicates that one always understands the world from a particular standpoint.

However, this perspectival view of understanding does not indicate a pure relativism of opinions either because of the way that Gadamer conceives of the individual. He says, “the prejudices of the individual...constitute the historical reality of his being,”¹² which is to say that prejudice reveals the individual to be defined by the specific coupling of personal attributes and life experiences as they move toward the future. This notion of the individual suggests that the life that one is currently living is always affected by the life one *has lived*. In this way, prejudice indicates that history and individuality are inseparable. This assertion is basic to hermeneutics. On this point, Gadamer claims, “what distinguishes the process of refining hermeneutic practice from acquiring a mere technique...is that in hermeneutics history co-determines the consciousness of the person who understands.”¹³ So unlike method, hermeneutic practice constantly builds one’s history into one’s current situation. This history thus becomes part of one’s understanding and identity.

Such a conception of individuality raises two important points related to design: first, that this notion of individuality is nothing willed; rather, it is existentially determined. And second, individuality and its understandings are always provisional. In other words, understanding is never something one can finish; rather, it is a dynamic ongoing process and is therefore always subject to revision and/or elaboration. Just as a good orator “respects” the audience by taking seriously their reactions to the discourse and adjusting for optimal communication, so too a designer must respect new discoveries within the course of design and respond in kind, so as to find the optimal fit.

This notion of the individual suggests that the life that one is currently living is always affected by the life one *has lived*. In this way, prejudice indicates that history and individuality are inseparable. This assertion is basic to hermeneutics.

CRITICAL RHETORIC

Gadamer once stated, “I would like to see more recognition of the fact that this is the realm hermeneutics shares with rhetoric: the realm of arguments that are convincing (which is not the same as logically compelling).”¹⁴ Gadamer argued for the importance of rhetoric because blind allegiance to methodological proof suggested a lack of aplomb in dealing with those “fundamental orders of being that are neither arbitrary nor manipulable by us.” When one forgets the rhetorical dimension then, “the only thing that gives a judgment dignity is its having a basis, a methodological justification (and not the fact that it may actually be correct).”¹⁵

Design students are often drawn into a similar fallacy of methodological justification, believing that a good design is something that can be systematized and proven. For example, in studio project presentations my students tend to simply recount a series of operations that they performed: how they used such-and-such from one operation as the basis for the next operation. This chain eventually leads to their own project, which for them is “correct” simply because their account was logical and all the operational steps can be shown to have a rationale. In short, a process based on such methodology obscures the need to analytically explicate experience, activity and event. The path toward correcting this dependency within the context of architecture is clear: by acknowledging that every project is an argument. Architecture is, fundamentally, an art of interpretation. Because of this, there are always a number of different approaches and results that may prove valid. Therefore, employing a methodology of certainty in architecture (i.e. this is the answer because it is the most logical) can produce flaccid results at best. Simply put, persuasion is part of architecture. And the reason to acknowledge this fact is not so one can better “sell” a building; rather, it is so designers will push themselves to ask “what is compelling about my ideas and observations, what makes my project worth caring about, and how do I best communicate and develop these things?” In overlooking the rhetorical aspect of architecture, we forget that a good design must ultimately stand on its own terms and be evaluated materially and experientially as such. The temptation to eradicate uncertainty misconstrues design as a logical flow of decisions and developments that can be shown to work in definitive terms.

Developing the experiential attributes that communicate design quality necessitates that designers inhabit the ambiguous space of their own evolving design. It is exactly in this uncertain space that hermeneutics helps designers. Hermeneutics frames an approach to design that engages the complexity of experience as such. It acknowledges that truly understanding complexity demands that one become part of it, and that in becoming part of it one can more

effectively find relevant information. Martin Heidegger characterized this involvement as “the anticipatory leap forward: not positing an end, but reckoning with being-on-the-way, giving it free play, disclosing it, holding fast to *being-possible*.”¹⁶ This description points to the so-called “hermeneutic circle,” which envisages a *seeming* tautology of developing understanding by acting upon understanding. However, the circle does not foster inaccuracy or redundancy. Rather, it frees the necessary and productive movement of interpretation; it delineates a practice enmeshed in specificity, variability and temporality.¹⁷ As such, it produces a markedly different type of “understanding” than what one might characterize as intellectual, strictly speaking.

Such understanding resonates in ways that are more akin to conversation than, say, reading a technical manual. For example, imagine going to a potential building site for the first time. In these visits there is always a first impression (even if it is the impression of banality). This initial impression resonates as definite feelings with indefinite architectural implications. This rift between *definite* feeling and *indefinite* application shapes the space of the design problem. Here, one might “measure” particular aspects of the site against one’s impressions to see which elements and relationships hold significance. These significances could be used to generate provisional architectural responses, and the proposed architectural interventions could in turn reorient one to both the site and their initial impressions, revealing new perceptions about both. In a recent student project for a synagogue on a busy intersection, many students became stymied by the potentially negative impacts of the traffic. One student, however, saw that this site was quite possibly the marquee location in town—a site where two major roads meet the edge of Main Street. This particular vision offered an optimistic way of dealing with traffic by standing up and addressing it rather than retreating from it. A host of ideas and architectural iterations flowed from the student’s commitment to this idea. The point here is that honoring the prejudice of one’s impression as provisionally true – and responding as such – allows a whole field of inquiry to open up. In effect, the feedback of encounter nourishes one’s ability to further engage the encounter. In this way, hermeneutics practice becomes a particular process of uncovering and investigating a growing web of possibilities and understandings. To be more effective, designers need to be constantly building up their design “prejudices.” This means fostering learning that builds embodied knowledge and tacit skills.

For designers this type of acquisition depends upon, fundamentally, the making of things, not as a proof of concept but as the very process of thinking and understanding. Here, respect and prejudice provide entry points into a problem and design plays out as the “process of correction.” This type of creative process demands a

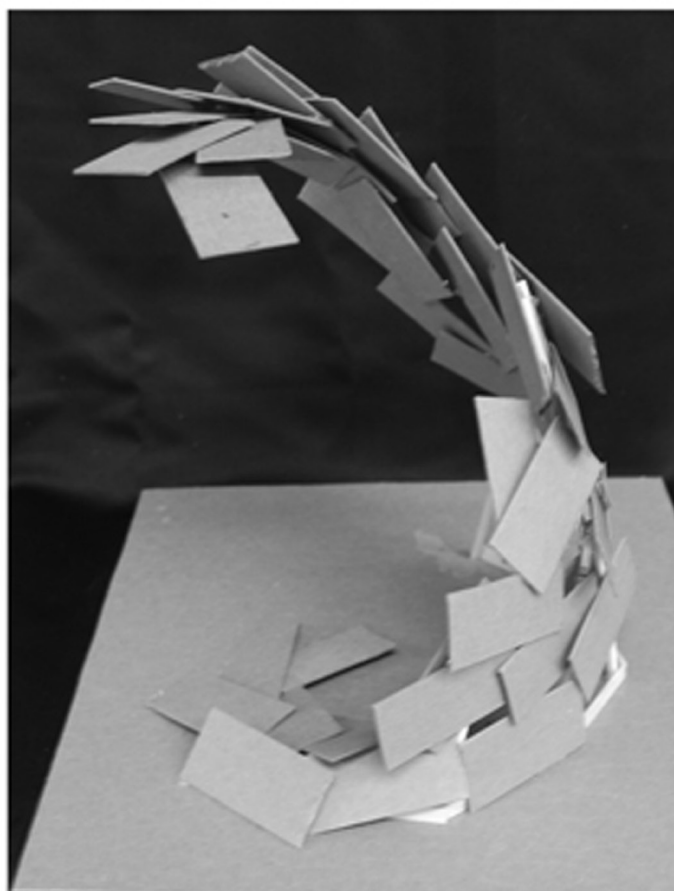
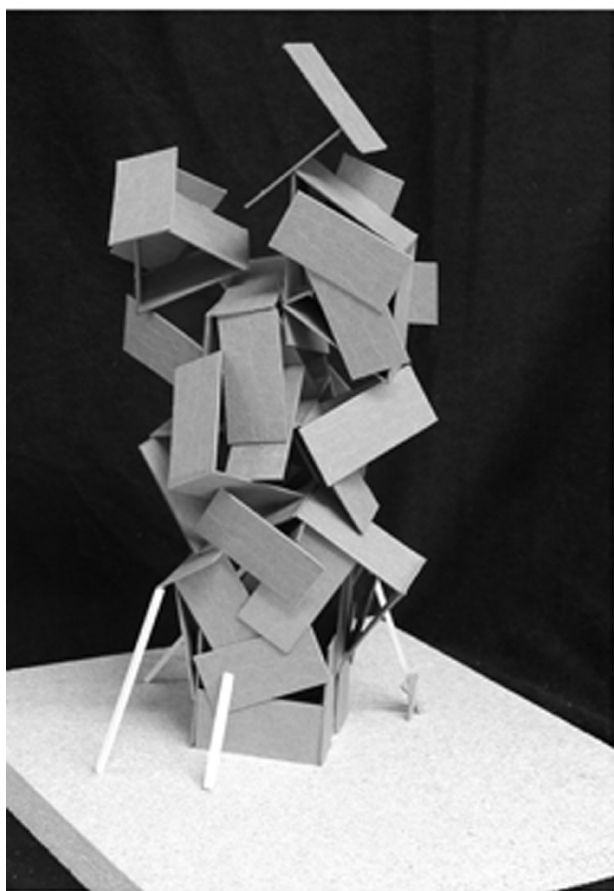
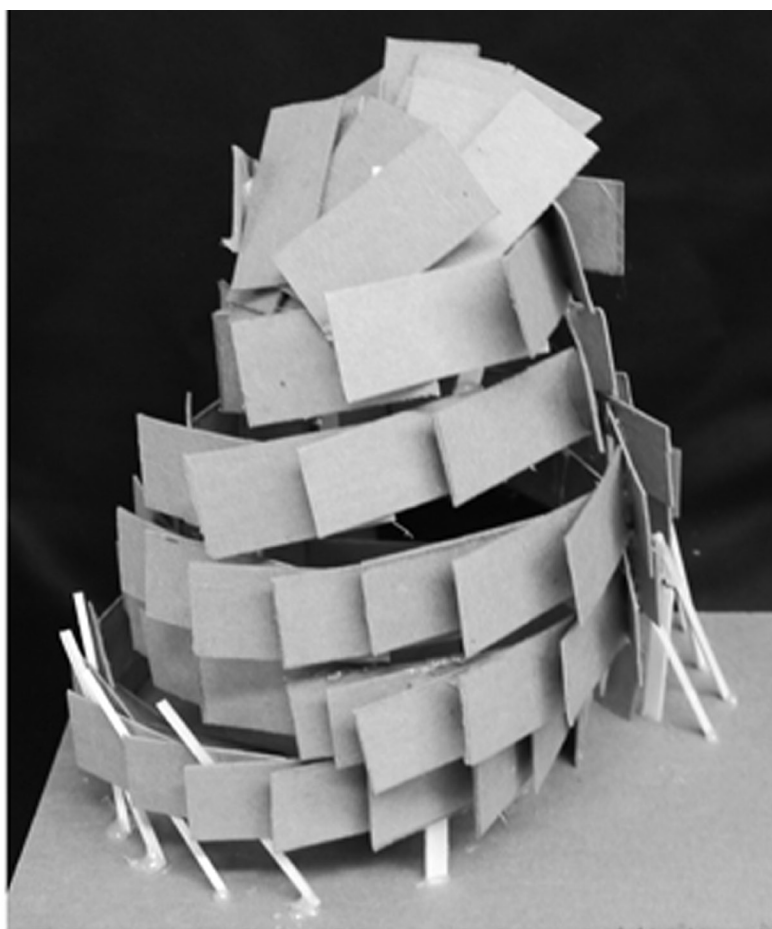
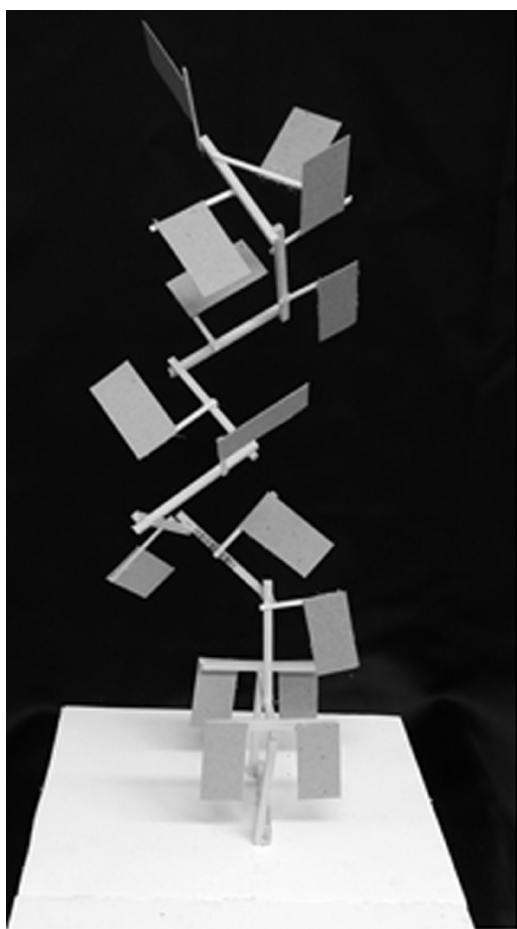
willingness to be affected by the peculiarities of every specific problem, realizing, as Heidegger pointed out, that thinking is at its most fundamental and effective when it is understood as a process for *allowing things to reach us*.¹⁸ In so doing, one moves away from either method or the individual as the source of creativity. Or, as Bruno Latour says, “hermeneutics is not a privilege of humans, but, so to speak, a property of the world itself.”¹⁹ In short, this play of prejudice and respect with the world points to a creative thinking that is not systematic, nor willed, but rather performed.

Gilles Deleuze and Felix Guattari have suggested that a disposition that allows things to reach us is closely aligned with short-term memory. They explain, “short term memory includes forgetting as a process; it merges not with the instant but instead with the nervous, temporal, and collective rhizome.”²⁰ That is, self-forgetting indicates a total immersion in the temporal flow of the situation. Gadamer actually turns to the activity of play as a means of activating self-forgetting. He says, “play fulfills its purpose only if the player loses himself in play.”²¹ And, in a posthuman spirit similar to that of Deleuze and Guattari, he claims, “it is the game that is played—it is irrelevant whether or not there is a subject who plays it.”²² In other words, mastery comes not from the players but from the game itself.²³ This attitude is different from the control that is sought in more reductive instrumental methodologies, in which the end is everything. To play the game requires that one abide by its structure and rules, allowing oneself to be swept up into its playing to be effective; and critically, as Gadamer puts it, “the purpose of the game is not really solving the task, but in ordering and shaping the movement of the game itself.”²⁴ In this way, understanding is the activity itself.

Here, it is important to indicate that this kind of play requires not frivolity, but seriousness. Gadamer posits, “seriousness is not merely something that takes us away from play; rather, seriousness in playing is necessary to make the play wholly play.”²⁵ Such focus begets the self-forgetting that ensures the completeness of one’s involvement. And when artists and environmental designers engage their work as this type of play, they connect with the rhythms of life itself. As such, the seriousness of play can yield profound revelations. Or as Friedrich Schlegel says: “all sacred games of art are only a imitations of the infinite play of the world, the eternally self-creating work of art.”²⁶ Teaching students how to play seriously enables hermeneutics to be vital as a design process.

Music can be helpful in demonstrating this sort of understanding. In listening to music, one is struck, overtaken by a definite feeling that asks not for one to solve anything, but rather to participate. Here, the “understanding” of music highlights those embodied intuitive capacities that we all possess. Hence I often ask students to create works in response to a musical piece as a means of entering into this kind of participatory understanding. Creations have included pastel drawings, collages, kit of parts sculptures (fig. 1-4), and

[right] *Figure 1-4: Musical kits-of-parts sculptures. Clockwise from top left: Jeff Jacka, Morgan Mende, Blake Wilson, Lauren Kopp. Photographs taken by author.*



architectural follies. The ability to engage architecture in this way provides an important counter-balance to the top-down formalism and instrumental problem solving associated with positivist method. Interestingly, despite being able to listen to music and enjoy it without intellectualizing, many will, when given the task of making something tangible in response, become wooden and immediately move to a more measured construction. Here, it is crucial to practice developing strategies to open non-intellectualizing dispositions and perspectives that place tacit knowledge in the center of interaction. However, facilitating this practice often requires pedagogical constructs.

One such construct was my use of a “program” made of excerpts from William Gibson’s novel *Neuromancer*. I used these excerpts as a device to push students toward viewing “program” more as an indication of a temporal world of potential events, interactions, and activities than as a series of spatially related, quantifiable functions. In this exercise, the goal was to focus the visceral, experiential, and temporal aspects of architecture by dematerializing the typical criteria by which many justify the correctness of their architecture. In so doing, we hoped to make students to dig deeper, to take risks, and to develop the rhetorical aspects of their designs—things that that they could not prove to be good via methodological logic; but instead, had to be developed into a compelling visual argument. Here, the effectiveness of a design would rely heavily upon the persuasiveness, the environment, and the quality of representation.

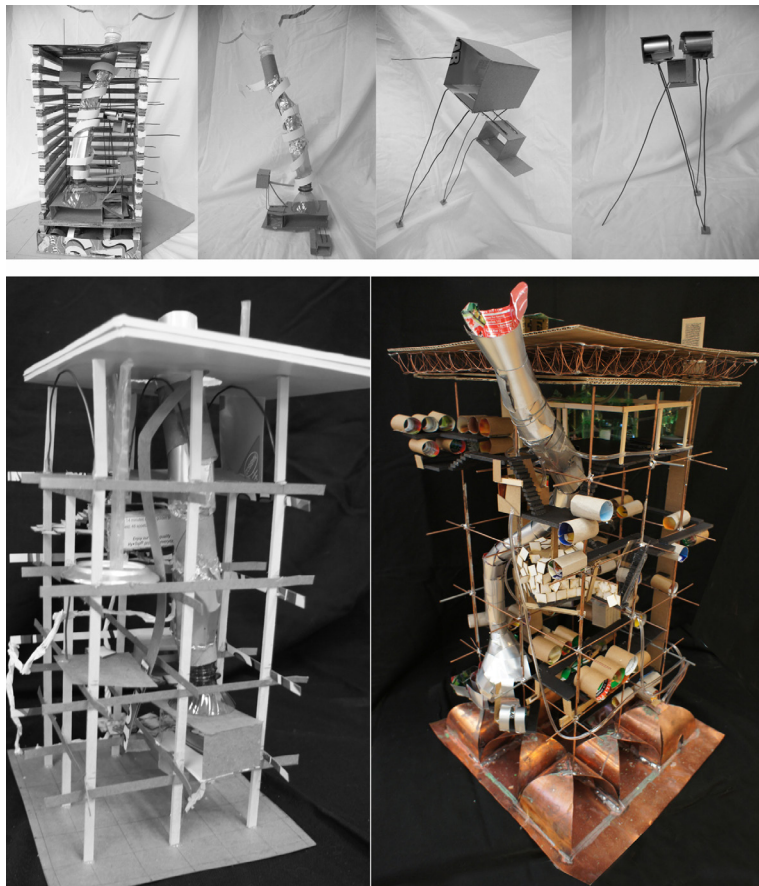
In starting out, students were both enthusiastic and confused—to me, this is a positive combination. The French writer Alfred Jarry once gave a meandering lecture, after which a gentleman remarked that he had found it interesting but had not understood a single word. To this Jarry retorted, “that’s exactly what I wanted. Talking about things that are understandable only weighs down the mind and falsifies the memory, but the absurd exercises the mind and makes the memory work.”²⁷ In a similar fashion, the students’ confused enthusiasm was a positive response because it intimated that they were prepared to exercise *their* minds as well.

Despite their enthusiasm for something new, many students’ first inclination in response to the brief was to make typical space plans of the program. I was a bit taken aback, given the freedom offered by the literary ambiguity of the program, that so many brought *only* standard program diagrams to our first pin-up. Yet, such an inauspicious beginning highlights the value of promoting design as a process of correction—even producing enigmatic fragments is better than not producing because it is this kind of active making that energizes the process. Further, these responses illustrate that prejudice *is* one’s starting point. Students necessarily produce something from a perspective they have experience in; the materialization of this perspective is valuable because it reveals the limitations of that perspective and offers a position to understand what this perspective and its products lack. As an aside, these initial

student moves reinforced how deeply seated predilections toward intellectual, rational approaches to problem solving are in students. Hence, the Gibson passages were used to problematize these approaches and the notion that there is a “correct” thing to do in design. In other words, in a world such as the one described in *Neuromancer*, just about anything goes; in fact, the weirder it is probably the more appropriate it is. So with the traditional logic of even the most basic requirements of architecture thrown out—no ADA, no codes, no sustainability, etc.—students have little to grab on to and are left to negotiate the uncertainty of the text itself. In short, students were forced to struggle with the question of what qualifies as good architecture when methodological reason no longer holds sway.

In this project, I gave two different versions of the program. One program focused on a section of the book that described the character Julius Deane’s warehouse, and the other focused on a description of a place in the city called the “cheap hotel.” The Deane description provided quite a few details about Deane and his lifestyle, whereas the portion about the cheap hotel mainly gave atmospheric descriptors about the hotel and its neighborhood. What was interesting in the student responses to the different programs is that initially the Deane warehouse passage appeared to be a more fruitful resource. It generated many more ideas and general enthusiasm from its designers. In large part, this was because Deane was seen by many to be akin to a client with characteristics and implied desires that could be ascribed architectural function and tangible value. With this reading of the brief, a number of students got into questions about Deane’s psychology and the space that they imagined he might want to create for himself. Despite the seeming usefulness of such readings, it seems that in the end many of the “cheap hotel” projects were actually more compelling. One reason for this, I believe, is connected to Jarry’s comment about the absurd in that the cheap hotel resisted cataloguing and demanded that designers literally enter into the space that they were creating while they were creating it.

Unlike the Deane designers, the cheap hotel designers were unable to attribute the complexity of the described environment to the personality of an individual. This meant that the hotel designers could not justify particular things within their projects in terms of some personality trait or personal value. Instead, their proposed environments could only be validated through the very persuasiveness of their representations. And so, where many of the Deane designers ultimately found they could fall back into their predilections toward logical formal connections and explanations, most hotel designers could not. For example, one student picked up on the fact that Deane had a kind of suit fetish and turned this into a conceptual notion about fine detail; another made Deane out to be both secretive and megalomaniacal and therefore made a building that was closed and humble on the outside, grand and intimidating on the inside. These approaches were fine; however, such tight conceptual frames



[above] Figure 2: Developing a continuation of the narrative to frame to new program elements as an array of interrelated events by Molly Marineau. Photographs by author.

[right] Figure 3: Investigating and devising plausible construction techniques based on the perceived assets of the environment by Lu Wall. Photographs by author.

tended to become formal one-liners. When this occurs, program becomes mere filler, stuffed pragmatically into the conceptual container, leaving a poverty of real architectural nuance. In short, many Deane designers neglected the architectural environment itself in favor of formal confirmations of concept.

Conversely, because hotel designers were forced into the environment directly, many developed unconventional strategies for architectural understandings. For many, the very ambiguity of the passage pushed them toward cinematic approaches, ones that were affective and temporal and embraced the fact that architecture must be convincing and persuasive on its own terms. The students took many different approaches: one developed a continuation of the narrative to frame new program elements as an array of interrelated events (Figure 2); another investigated and devised plausible construction techniques based on the perceived assets of the environment (Figure 3); still another used found objects to de-familiarize the problem and break out of a typical space planning mind-set (Figure 4). All of these solutions embraced the rhetorical aspects of architecture, committing to and developing the persuasiveness of a spatial and materially affective sensory experience as a means of project validation. In this way, one can see how



a number of hotel designers invested in the power of the architectural space itself and developed it as such. As a result, their projects tended to show more potency and subtlety in their resolve than others that relied on the methodological construct and its corresponding arithmetic of justification. Certainly, other factors, such as individual skill, may have contributed to the results; however, the distinct difference in the perceived accessibility of the different programs and the distinctly dissimilar responses these perceptions spawned was undeniable.

CONCLUSION

A kind of faith is necessary for doing good design, but it is not blind. It is a faith in the practice that is one's design process. The first step to a hermeneutic design process is to build a genius for not-knowing. It is from this disposition that skills, tools, and devices become extensions of one's very being and allow one to act adeptly within the tiniest of possibilities.

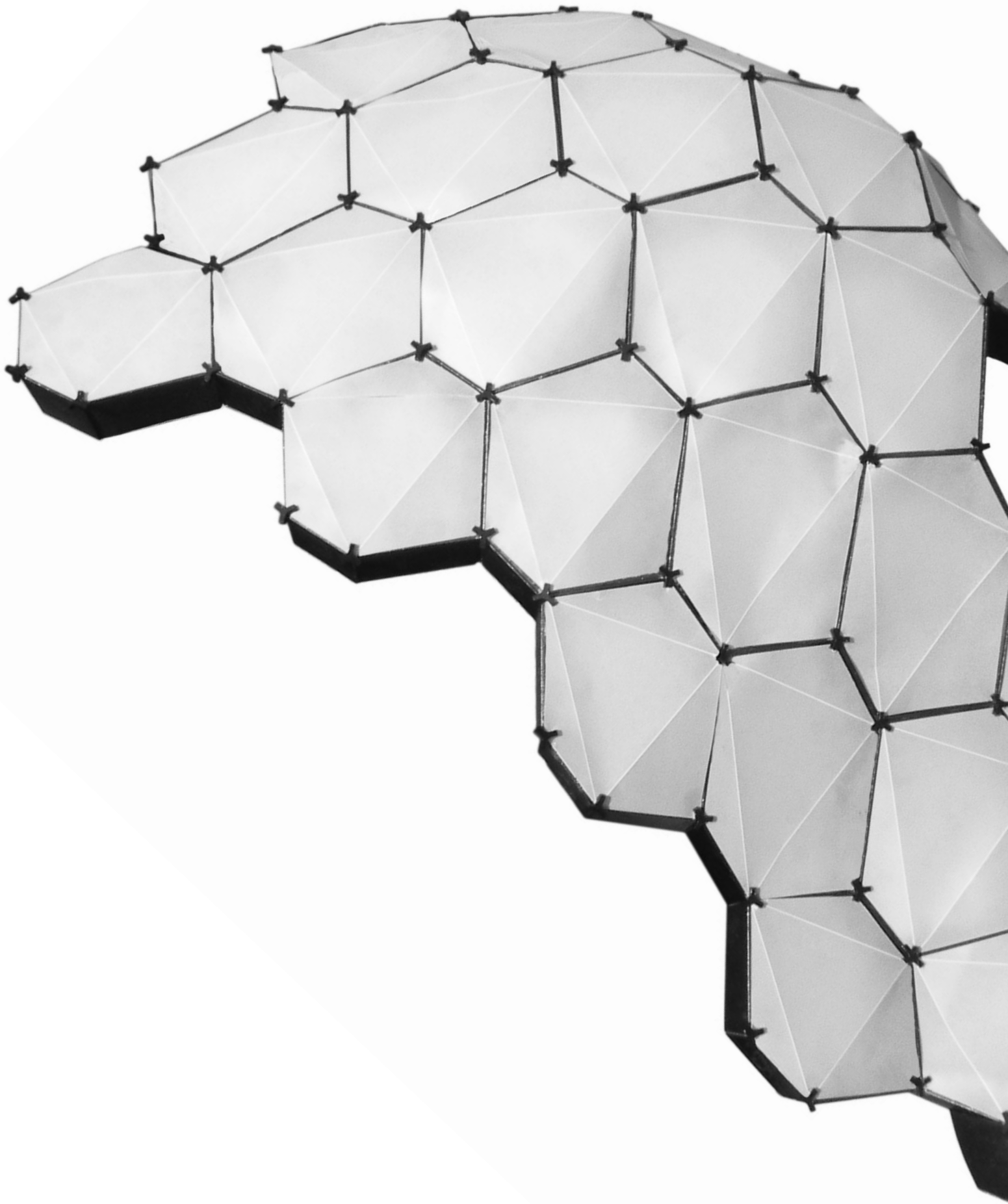
The importance of play in hermeneutic practice highlights the limitations of a process based on "method." However, play also points to the fine line that divides these two approaches. Like play, method endeavors to focus on the process itself rather than the end, but it does so in a way that relies on a separation between designer and process. In architecture, method pushes one away from both the experiential implications of architectural design and the importance of rhetorical understanding and communication in creating affective work. Play is the vehicle for hermeneutics because it is necessarily situational and involved, and is thereby more connected to existential and phenomenological issues. The vehicle of play allows for a unified functioning of prejudice and respect. Here, hermeneutic practice transcends the extremes of both method and egoism, offering a process where the designer is no longer building scientist or architectural artiste. Instead, the designer becomes "a possible path of being wakeful."²⁸

Moving toward this type of comportment requires that one develop capacities for a variety of temperaments, sensitivities, and tactics so as to better cope with difference and change. Hermeneutic practice orients one within such uncertainty so that issues, ideas, and possibilities need no longer be contrived, but rather can be imbibed and worked with as such.



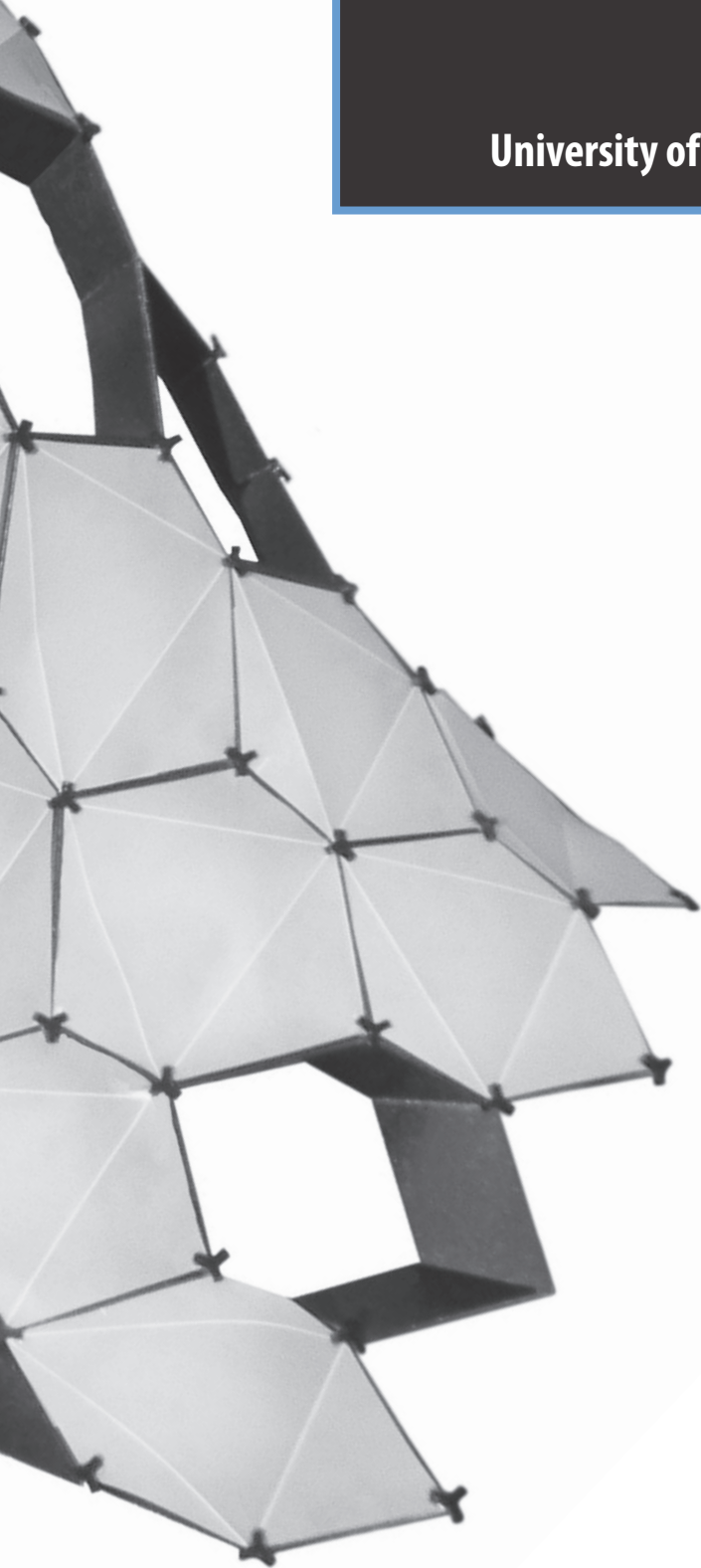
[above] Figure 4: Using found objects to de-familiarize the problem and break out of a typical space planning mind-set by Emilie Shimpach. Photographs by author.

- ¹ Bruno Latour, *Reassembling the Social: An Introduction to Actor-Network-Theory* (New York: Oxford University Press, 2005), 245.
- ² Henri Bergson argued that intellect "...instinctively selects in a given situation whatever is like something already known; it seeks this out, in order that it might apply its principle that 'like produces like.'" Henri Bergson, "Introduction to Metaphysics," in *The Creative Mind* (New York: The Philosophical Library, 1946), 34.
- ³ Hans-Georg Gadamer, *Truth and Method*, trans. Joel Weinheimer and Donald G. Marshall, Second ed., (New York: Continuum, 1975), 157.
- ⁴ ———, "The Universality of the Hermeneutical Problem," in *Philosophical Hermeneutics* ed. David Linge (Berkeley and Los Angeles: University of California Press, 1967), 9.
- ⁵ Ibid., 4.
- ⁶ The Vitruvian category of delight is a paradigm example of such an order.
- ⁷ ———, *Truth and Method*: 560.
- ⁸ Ibid., 558.
- ⁹ Ibid., 273.
- ¹⁰ As cited by Andrea Branzi in, Andrea Branzi, "Fuzzy Thinking," in *Weak and Diffuse Modernity* (Milan: Skira, 2006), 18.
- ¹¹ Patrick Rogers Horn, *Gadamer and Wittgenstein on the Unity of Language: Reality and Discourse Without Metaphysics* (Burlington, VT: Ashgate Publishing, 2005), 12-13.
- ¹² Gadamer, *Truth and Method*: 278.
- ¹³ Ibid., 570.
- ¹⁴ Ibid., 571.
- ¹⁵ Ibid., 273.
- ¹⁶ Martin Heidegger, *Ontology: The Hermeneutics of Facticity*, trans. John Van Buren (Bloomington: Indiana University Press 1999), 13.
- ¹⁷ In *Being and Time*, Heidegger also warns against viewing such circularity as undesirable. He says, "if we see this circle as a vicious one and look for ways of avoiding, even if we just 'sense' it as an inevitable imperfection, then the act of understanding has been misunderstood from the ground up" ———, *Being and Time*, trans. John Macquarrie and Edward Robinson, Seventh ed. (San Francisco: Harper and Row, 1962), 194.
- ¹⁸ See, ———, *What is Called Thinking?*, trans. J. Glenn Gray (New York: Harper & Row, 1968).
- ¹⁹ Latour, *Reassembling the Social: An Introduction to Actor-Network-Theory*: 245.
- ²⁰ Gilles Deleuze and Felix Guattari, *A Thousand Plateaus: Capitalism & Schizophrenia* (Minneapolis: University of Minnesota Press, 1987), 17.
- ²¹ Gadamer, *Truth and Method*: 103.
- ²² Ibid., 104.
- ²³ Ibid., 105.
- ²⁴ Ibid., 107.
- ²⁵ Ibid., 103.
- ²⁶ As quoted in, *ibid.*, 105.
- ²⁷ Barbara Wright, "This Book, This Play, This Drama," in *Ubu Roi by Alfred Jarry* (New York: New Directions, 1961), VIII.
- ²⁸ Heidegger, *Ontology: The Hermeneutics of Facticity*: 5.



Teaching Digital Fabrication Techniques

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The use of digital fabrication in the production and making of architecture is becoming a prevalent vehicle for the design process. As a result, there is a growing demand for computer-aided design (CAD) skills, computer-aided manufacturing (CAM) logic, parametric modeling and digital fabrication in student education. Three student projects highlighted in this paper integrate computational prototyping with digital fabrication techniques in the production of architecture. The goal is to teach fabrication techniques of sectioning, tessellating and folding to educate students in CAD, CAM, parametric modeling and digital fabrication. Mixing fabrication techniques challenges students to understand CAD techniques or parameters for modeling thereby providing greater design agency. Translating prototype designs for CAM production engage real world constraints of materials, time and tectonics. In the end, these projects demonstrate how digital fabrication techniques affect technological understanding and making in an age of digital ubiquity.

INTRODUCTION

Digital fabrication techniques emerge from Lisa Iwamoto's book, *Digital Fabrications, Architectural and Material Techniques*. The professional and academic projects she discusses review fabrication techniques developed over the last decade: sectioning, tessellating, folding, contouring and forming. The book showcases impressive case studies demonstrating "how designs calibrate between virtual model and physical artifact" (Iwamoto 2010). The projects explore the idea of Computer Numerical Control (CNC) craft and the relationship between the workmanship of certainty and risk and the resistances of making. David Pye's (1971) book *The Nature and Art of Workmanship* introduced us to the concept of workmanship, which according to Luis Eduardo Boza (2006) the workmanship of risk "relies on a personal creative knowledge of the tools, materials and techniques." CNC craft, one CAM tool, represents both a workmanship of certainty in the precise numerical control used for manufacturing and risk in how students creatively leverage this certainty to produce a prototype. Therefore, in the prototyping activity is the resistance of the tool in how it is used, the resistance of materials as they are subject to the tool to produce the prototype.

The design trend that has emerged is evolving the certainty of digital fabrication toward the notion that "we can use digital fabrication as a catalyst for design instead of just a means of production." (Cheng and Hegre 2009) As such, digital fabrication techniques provide a creative and critical design process and challenges the notion that the certainty of machine craft removes the "risk and the critical creative role of the craftsman/artisan, are taken out of the equation." (Boza 2006) Instead digital fabrication elevates the creative power of making, leveraging the certainty with the creative affordances inherent in risk.

Dimensional precision of CAD environments that drive CAM tools is necessary for creating complex, curved geometry and architectural surfaces. The surface can be a powerful architectural gesture embodying complexity and sophistication. The following projects explore the relationship between building surface and structure as a CAD generated form and a CAM fabricated tectonic. The design process used two fabrication techniques to create a "skin" surface and "bones" structure. To start the design each student used two out of three fabrication techniques: sectioning, folding, and/or tessellating. Students referenced these techniques and investigated other design projects based on Iwamoto's book.

Many of the digital fabrication projects directly benefit from the creative application of sectioning, folding or tessellating techniques through exploiting singular operations repeatedly. For the folding technique, projects such as Dragonfly designed by Tom Wiscombe/

EMERGENT and Manifold by Andrew Kudless/Matsys both utilized the folding technique to create a hexagonal structure, but were fabricated in very different ways using two different materials. The tessellating technique is exemplified in Living Light designed by Soo-In Yang and David Benjamin and the Puppet Theater by Mos with Huyghe. While the Puppet Theater aims to rationalize the tessellated surface by using a triangulated panelization, the Living Light dome follows the structure more closely using hexagonal panels for the surface.

The formal installations and material effects represented in these designs evolve from digital fabrication techniques, tessellated parts and folded geometry. The projects and installations exploited the laser cut or CNC profiled panels to produce altered visions of surface, structure and space. However, in the repetitive and scalable variation of similar tessellated pieces created with a single operation is how digital fabrication techniques become common or normative in their use of CNC craft. “Strategies for articulating the tectonic of NURBS-based envelopes are driven by their geometric complexity” (Kolarevic 2003, p42) and as a result the “rules of constructability” have led to common geometric rationalization strategies. The author’s intent is to highlight the results of teaching digital fabrication techniques from Lisa Iwamoto’s book and to move beyond the normal singular technique of digital production. Results are summarized in each section through a discussion on what the students learned in the completion of the project.

Three student project examples mix the conventional digital techniques of sectioning, tessellating and folding as explorations in CNC craft. The organization of the discussion that follows begins with a short overview of the project, discussion of the CAM process used in production and a reflection on the fabrication. Each project highlights the opportunities, the lessons learned and the resistances encountered in the making of each product.

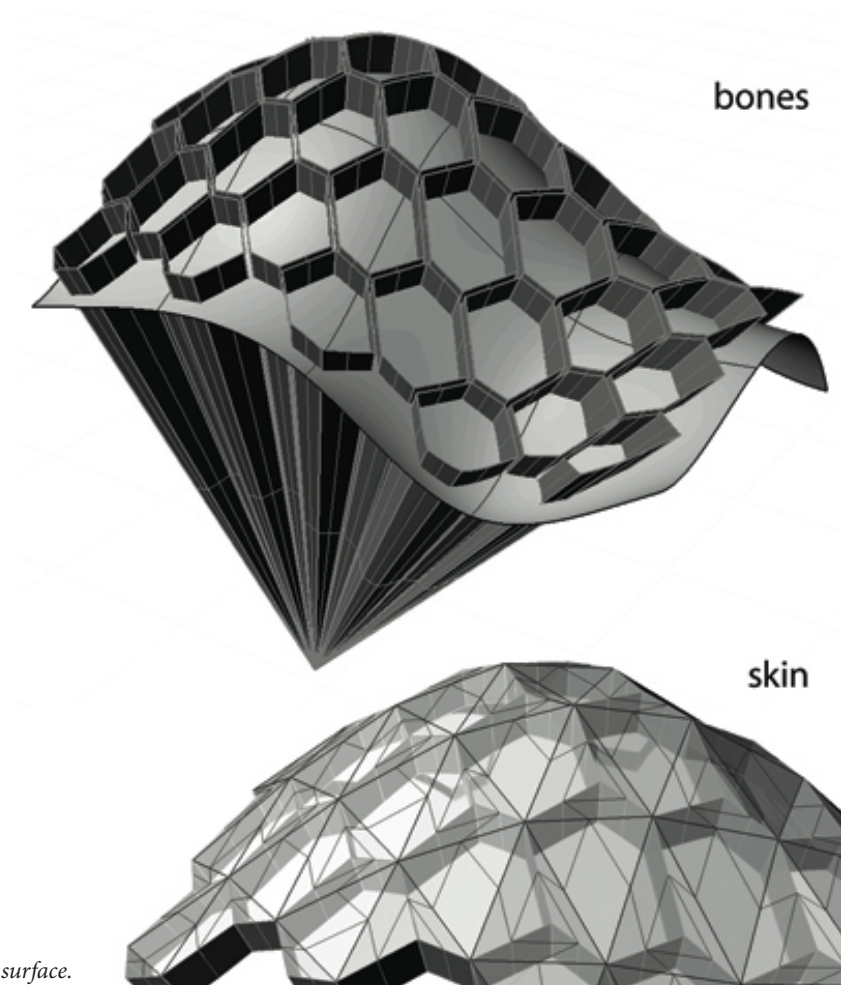
BEE’S KNEES

The first project was inspired by Manifold by Andrew Kudless. Bees Knees built on the hexagonal folding technique for the structure and added a triangular tessellation to represent a doubly curved surface. The students used Rhinoceros CAD software and a Grasshopper plug-in to rationalize the honeycomb structure and tessellated surface (Figure 1). Beginning with a flat 16” by 32” surface, pushed and pulled control points within that surface make the object curve in two directions.

The students decided to fabricate the structure of the surface first using the honeycomb technique. To develop this structure they applied a packaged script, Honeycomb_Basic, to the surface to get the hexagonal structure output. Then, using the Rhinoceros UnrollSrf command, separated the structure into individual strips for the laser cutter. These pieces were cut, scored and folded back and forth to physically

fabricate the structure; much in the same way the Manifold project was fabricated. Once completed, students discovered the script used to produce the surface did not account for material thickness resulting in assembly problems. Using a different technique with a Grasshopper definition called HoneycombCladding resolved the material thickness issue. This definition rationalizes the honeycombs into cells, similar to the Dragonfly project, as opposed to the folded back and forth strips. By using the ExtrudeCrvPt command, this produced a series of flat surfaces for each segment of the cell, thereby preventing each member from twisting, which was necessary when considering real world application with flat stock materials.

For the tessellated surface, students first manually created triangulated panels on top of the honeycomb structure in the Rhino model, and then again used the UnrollSrf command to lay out each triangle in preparation to be cut out of a flat material and applied to the curvilinear surface (Figure 1). After fabricating these pieces, due to the flexibility of the structure material, rigidity of the surface material, and triangulation of the surface, the “skin” and “bones” did not perfectly mate. Resolving this involved a triangular surface tessellation based on the hexagonal shape of each cell.



[right] Fig. 1. Honeycomb folding and tessellated surface.

CAM Process

The first part of the fabrication process began with using the laser cutter to make the structure (Figure 2), then unrolling each surface in Rhino and laying them out within the dimensions of the laser cutter bed (32" X 18"). To keep each piece in order, they were individually numbered and each segment scored based on which direction it is supposed to fold. Finally, the strips were adhered to the segments that shared a side with one another.

For the next step, students used RhinoCAM to generate the g-code for the CNC machine, which fabricated the skin cutting out each triangulated piece from ¼" thick plywood. This was not the best process for fabricating the surface due to the thickness and rigidity of the material and the blunt nature of the CNC machine on smaller delicate pieces. Instead, students used the laser cutter to cut out the triangulated pieces of thin acetate. While cutting the acetate, the heat from the laser caused the pieces to melt back together, which caused the sheet to be more scored than cut. The next issue was how to adhere the pieces to the structure, which did not line up due to the rigidity of the acetate and the flexibility of the chipboard.

The final fabrication process incorporated the 3D Printer, which was well suited for the structure due to its rigidity and accuracy (Figure 2). Due to the size requirements of the final product and the limitations of the 3D printer bed size the entire model could not be fabricated using this process. Following several prototypes to rationalize the geometry for the fabrication process of this doubly curved surface, work began on the final model.



[above] Fig. 2. Honeycomb folding and tessellated surface prototypes from left to right; chipboard structure, 3d printed bones and paper skin/bones units.



To complete the project, they laser cut 2-ply chipboard to form the cellular honeycomb structure. After each of the folded cells turned into their final shape, each cell joined with its neighbor to form the doubly curved surface. The chipboard structure coated with several layers of gray primer and black metallic spray paint gave the model a more polished appearance. A Y-shaped connector piece cut from black acrylic joined the skin at nodes within the structure. The proper shape of the skin was formed from each cell's printed-paper template. The skin used vellum as the material for its flexibility and semi-transparent character. The laser cut and etched skin pieces were folded before being adhered to the acrylic connectors and the structure.

Fabrication Reflection

Through this process, students learned that the accuracy of the CAD output for CAM production is not always exact or completely reliable. Material thicknesses can be inconsistent and accounted for in the design. In this project (figure 3), due to the CNC precision, the skin did not allow for any error. Students encountered tolerance issues in the connections between the skin and cells. Allowing more flexibility in the joining of the skin material to the cellular geometry of the honeycomb would resolve this issue. Additionally, the final spray painted structure deformed the model, which caused the final vellum skin pieces to fit slightly twisted. This resulted in each cell of the bone structure to be readjusted as each skin piece was inserted. As the fabrication progressed, the pieces began to fit more accurately. The reveals in the model showcased the various angled geometry of the structure as it relates to the skin.

[above] Fig. 3. *Bees Knees* project by Kate Sloniker and Katie Johnston, University of Nebraska-Lincoln, College of Architecture.

SPACE(D) FRAME

Fundamentally, Space[D] Frame was a project developed by integrating digital design and manufacturing techniques with rapid prototyping to produce a double-curved surface. The project utilizes the integration of two distinct digital fabrication techniques, sectioning and folding, one for the production of structure and the other for its cladding (figure 4).

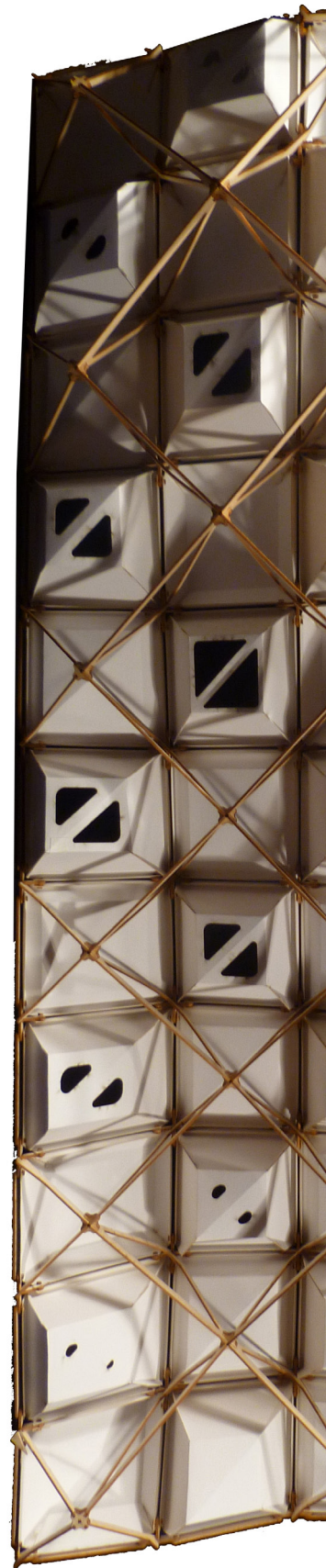
Structural grid lines, or ribs, were defined by using a sectioning technique and then extrapolated to define a truss system. An integrating series of joints and members throughout the system allowed the project to be hand-assembled and the cladding integrated into the structural grid.

Cutting and scoring flat material created the cladding from a folded flat surface defined as a three-dimensional self-supporting shape. The cladding enhances the undulations of the surface by exploring the variability of a single-folded system parametrically applied to a double-curved surface. Through a prototyping process, every element of the cladding integrated into a single unit that could be laser cut and scored.

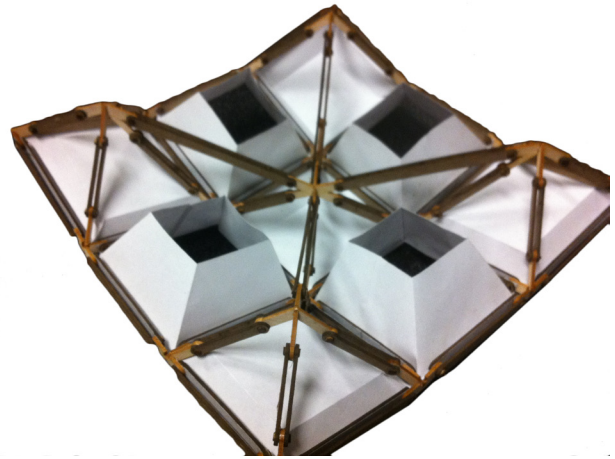
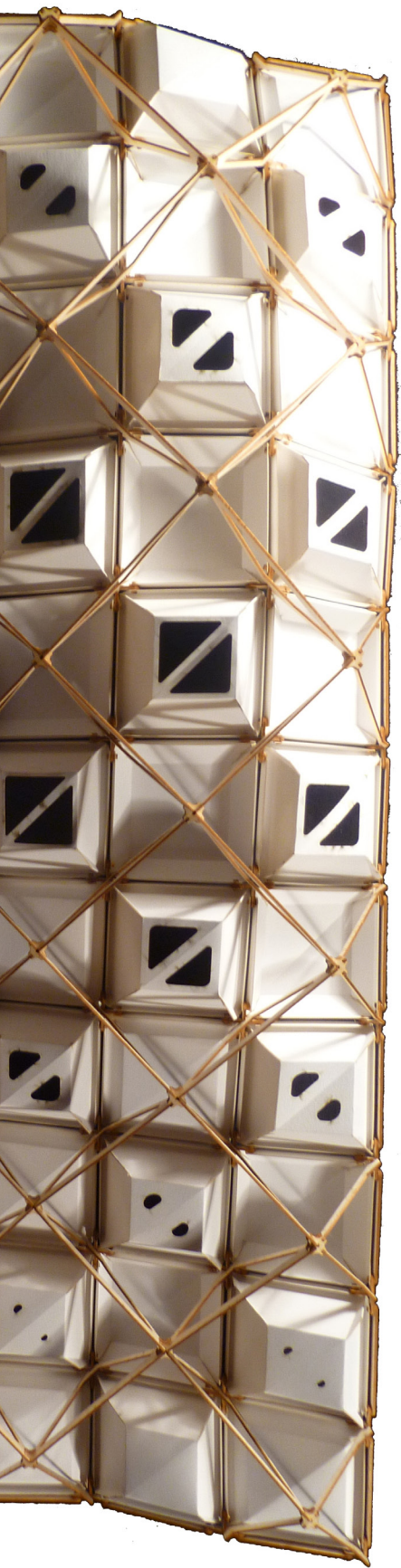
CAM Process

A series of iso-curves divided the initial double-curved surface and were then exported for the development of the structure and the cladding. Precise CAM methods independently, digitally, and physically produced the structure and skin. Prototypes produced aided an understanding of tolerances between the structure and cladding definition based on the initial iso-curves. As a result, the structure and the cladding did not need to be joined until the final physical assembly. Instead, each part seamlessly integrated into the other to the degree that previously designed structural elements could be replaced by the folded cladding units.

To begin the iterative design process, a prototype of the structure defined a relationship to a flat plane. By simplifying the structure to such an extreme degree, complex elements of the design could be thought about first in simplified conditions before being defined with more complexity. The sectioning technique and structural pattern digitally defined the double-curved surface. The surface was prototyped as a simple cardboard model with members that spanned the full length of the model. Although it effectively produced a double-curved surface, it was lacking in cladding and an elegant system of production. A skin soon began to populate the structural units of the prototype by folding units over its members. The prototyping process then began to focus on the cladding units and how they were able to occupy the built surface. In turn, this identified the need to better integrate



[above] Fig. 5. *Skin and Bones final prototype.*

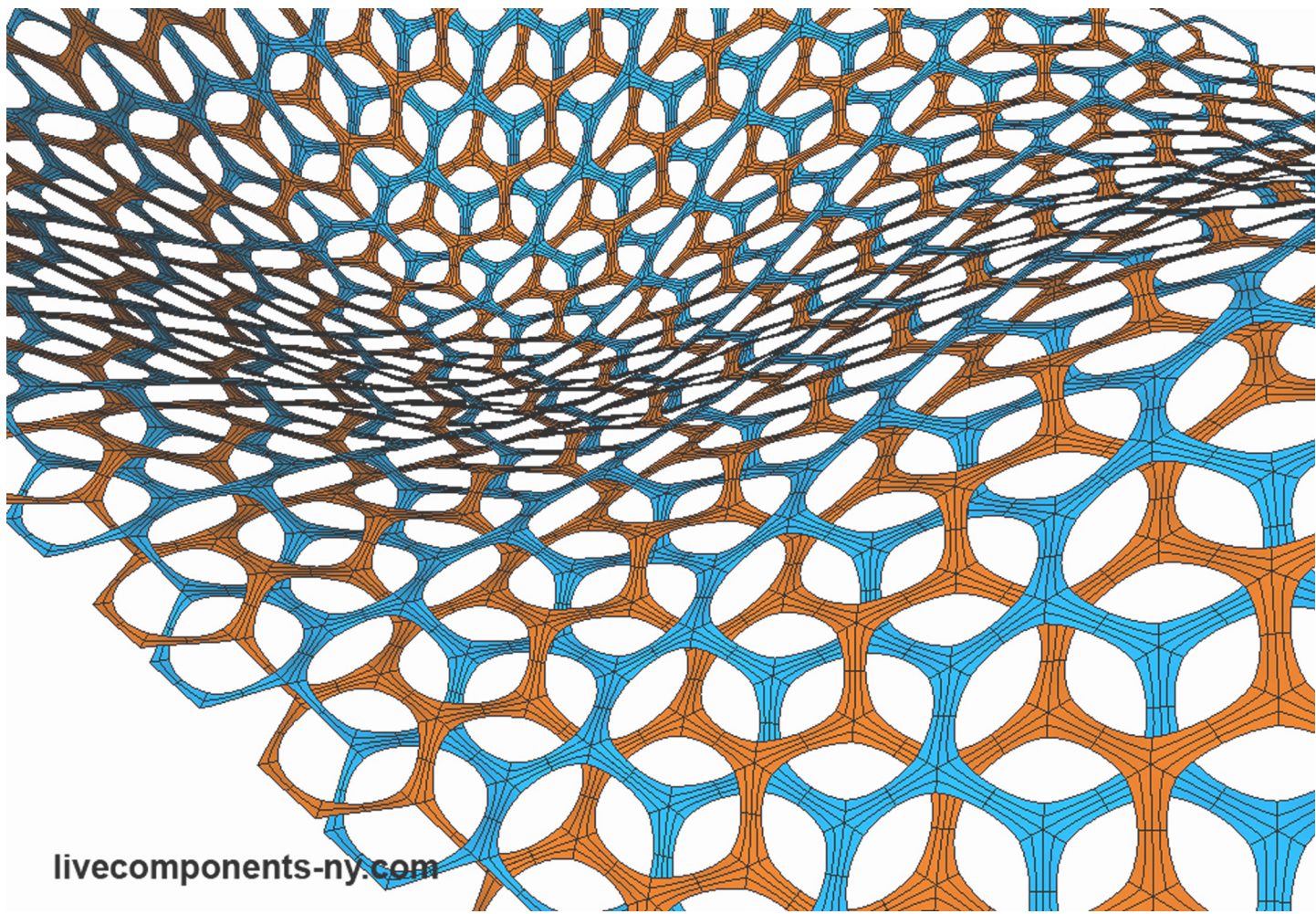


[above] Fig. 4. *Skin and Bones prototype.*

the two distinct systems. Simultaneously, the structure and cladding developed at a staggering pace. The structure was divided into members and joints and the cladding's folding systems became more defined as enhanced ways of folding the units emerged. The joints became the connections between the cladding and structure and a iterative refinement of the structure began. With each iteration, complexity and elegance were gained. Several similar member and joint strategies defined the resulting series of custom trusses to form the structure, as well as a unique system of custom joints and semi-uniform members that connected the structure to the cladding. These semi-uniform members connected the structure and the cladding at the perimeter of the design creating a finished edge.

Fabrication Reflection

The design intent, realized through a highly iterative process, created a digitally produced double-curved surface as a physical model composed of two parts: the bones or structure and the skin or cladding both defined by the surface. By heavily utilizing CAM software, in this case Rhino and the Grasshopper plug-in, multiple techniques explored solutions virtually before manufacturing the material. Through the use of digital software a high level of design collaboration oscillated between designing structure and skin, thereby achieving high tolerances when moving in the manufacturing phase. Critical in this digital exploration were the design of the structural joints as well as the folding technique of the skin.



FLUID WEAVE

The intent of this design was to creatively explore and push the limits of a doubly curved surface in both the terms of computer generation and fabrication. The surface or “skin” manifested itself using a process of folding while tessellation defined the structure or “bones”. Two independent hexagonal tessellations that weave in and out of one another defined a complex system for the structure. The two are joined together using supports located at common points where the two grids overlap vertically. The rigid three-dimensional surface for the skin was constructed from folding sections of flat material.

CAM Process

Our inspiration for the design came from Hyoun-gul Kook, who had previously designed interweaving geometric patterns, figure 6. This was the initial inspiration for the structure and its weaving character. Beginning with an image of his work, the approach was to translate this into Grasshopper and create a form that was three-dimensional and would conform to the constraints

[above] Fig. 6. Hexagonal weaving study, credit Live Components
by Hyoun-gul Kook

imposed by physicality in the real world. The Grasshopper definition developed was able to define a variety of parameters based on the hexagonal weave to develop the structure, which was systematically applied to the doubly curved surface.

One consideration of digital design was deciding how the double-weave hexagonal parts would interact to create a structure. The digital realm allowed for the creation of a form that held its shape and position without any connections or technical feasibility. Grasshopper's parametricism allowed this problem to be solved by simply creating shafts that connect points between the double-weave. This saved time in the initial model prototype but also created different variations of doubly curved surfaces and sizes of tessellations to divide the grid. Finally, after much iteration ranging from pure geometric forms to complete fluidity resolution on the final model satisfied the students' aesthetic sense, while remaining within our means of fabrication.

Fabrication Reflection

After multiple failed attempts with the CNC router, pieces were fabricated using the 3D printer because of the high degree of accuracy achievable. This brought about its own set of challenges due to the brittle nature of the material. One technique that helped to counter this was the use of color which demarked the position of each piece and also strengthen the 3D print.

The skin presented its own set of challenges. The students' intent was that the cladding be planar, making it easy to cut out and assemble. The difficulty in the output was creating a polysurface out of a flat piece of material. In the end, the surface which was cut out of bristol on the laser cutter, required the edges to be scored, making it easier to fold the material into a three dimensional shape.

Examining the final model, figure 7, the techniques of tessellation and folding can be identified in the overlapping hexagonal structure and skin. Additionally, an effect of transparency begins to appear as the fenestration of the skin's panels change according to a curvature of the base surface. Although very ethereal, the model itself functions successfully, as the skin could not hold its shape without the support of the structure behind it.

The output of the final model taught students about margins of error as well as the importance of calculating and compensating for the inaccuracies of the human hand. Though the pieces of the structure were highly precise, human error in assemblage produced misalignment between parts that multiplied across the surface. In addition, constraints of material also made matters of construction difficult. With each failed iteration and unsuccessful model there came a learning experience. This taught the importance of

prototyping and its function in the real world.

Digital fabrication, much like architecture, truly is an iterative process of thinking, making, and rethinking. There is no straight line from conception to final product. Even if a first attempt is successful, one must always contemplate on how to further optimize the process in order to achieve higher quality, a quicker process and a more economical means of fabrication.

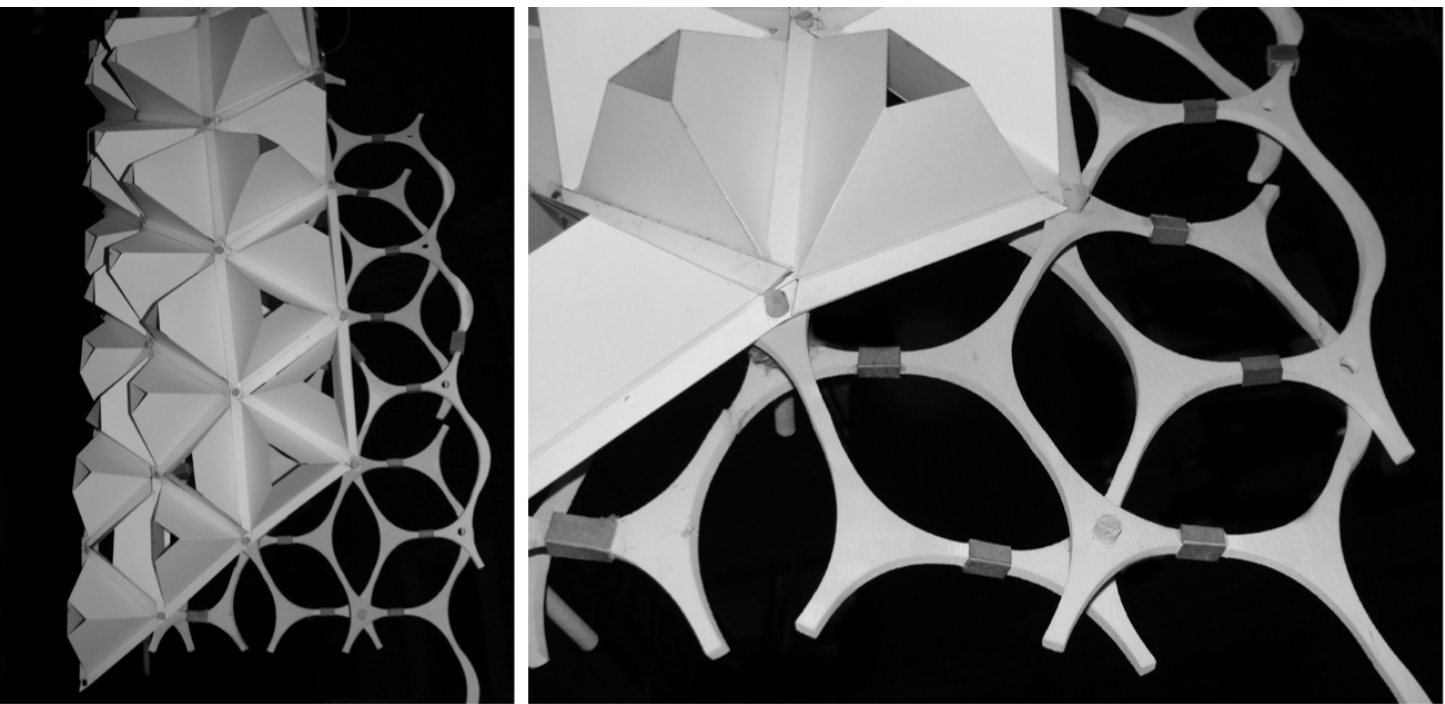
CONCLUSION

Emerging digital technologies used throughout these projects constructed architectural surface details. Digital fabrication integrates design process with production, where student learning is formed and informed from the unexpected resistances inherent in the design process. For example, the resistance of the materials used, the fabrication machines, the software output and the translation of CAD designs, via file-to-factory, for CAM production provided critical agency upon both the making and the production.

The three projects all succeed in incorporating sectioning, tessellating, and folding techniques in their projects. The first project, Bees Knees, highlighted a meticulous rationalization process of the double-curved surface into a skin and bones, hybridizing a folded structure with a tessellated surface. Bees Knees expanded the honeycomb script to include a triangular tessellated surface into the cellular structure. Next, the Fluid Weave project was successful in producing a double-hexagonal tessellated weave for the structural bones. Success relied heavily on the 3d printer to additively construct the complex forms. However, the overall folded surface failed to integrate into this underlying structural complexity. Finally, the Space(D) frame project did depart from conventional sectioning techniques, producing a double parallel space frame structure for folded tessellated inserts. The folded inserts were novel in the sense of the realization of variation and adaptation to resolve the curvature of the overall form. Each piece contains a similar genome, but must evolve to each site situation within the structure. Additionally, the structure adapted to the inserts inherent folded structural capacity. The folds provided enough rigidity that not all the structural cross members were needed, allowing the skin and bones to dissolve into one cohesive structure. Through combining digital fabrication techniques the normal singular production techniques become integrated into the design process affording unexpected opportunities.

As Branko Koleravic has described, “Designers are constantly looking for particular affordances that a chosen production method can offer, or unexpected resistances encountered...” (Koleravic, 2008, p127). Through integrating CAD design, CAM logic, parametric modeling and combining techniques of production afforded opportunity to create something. The student projects and descriptions in this paper describe how creatively leveraging the CAD/CAM process for design

[above, right] *Fig. 7. Fluid weave overall composition on left with detail of hexagonal structure and skin connection on right.*



departed upon the resistances encountered in the materials, tooling, and file-to factory process. Critical to the projects' success was the rapid prototyping capabilities of the 3d printer and the iterative file-to-factory prototyping engaged to produce multiple models. Teaching digital fabrication uses iterative prototyping of physical models to explore the agency of the detail and the agency of the digital. CNC craft embraces the unexpected resistances affording an opportunity to execute eloquent solutions that have departed from repetitive singular operations into something more.

The author would like to thank the students whose work and ideas are presented in this paper. Their efforts and writing helped inform the content of this paper. Thank you to Katie Johnston, Erik Leahy, Holden Rassmussen, Kate Sloniker Colin Spelts, and Bryce Willis.

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Throwing Paint:

Using Divergent Thinking to Energize the Traditional Design Studio

**By Sean M. Rotar, ASLA, Assistant Professor
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Divergent thinking, then, is a component of creativity that is necessary to a thriving design process since it is through divergent thinking that idea generation most often happens.

Designers seem almost intuitively to realize the value of exploring a variety of ideas, inputs, and interpretations as part of their design process. During this exploration, practitioners explore numerous design concepts, mine a variety of sources seeking inspiration, and follow multiple methods of idea generation, all with a rational goal: to explore a full range of creative solutions to a problem before determining the most appropriate response. Though most designers take this approach, undoubtedly few have considered their ability to think in this way, and fewer still have contemplated how this way of thinking entered their design process and the effect this thought process has on the solutions and ideas they create.

Divergent thinking, a concept developed in the 1950s by psychologist J.P. Guilford, is an intellectual process that allows for a free and creative generation of many different ideas in a short period of time.¹ Divergent thinking is usually a spontaneous exercise: writers, for example, use divergent thinking processes when brainstorming ideas or freewriting—writing in short bursts of fixed duration on a single subject. The primary use of the divergent thinking process for designers comes in idea generation, the rapid production of design ideas – similar to a writer’s brainstorming-- that involve little initial evaluation of the idea’s worth; rather, the designer is attempting to bring forth as many ideas as possible that might solve the problem at hand, or that might become part of an amalgamated solution.

Guilford also recognized this way of thinking as a major component of creativity.² He defined four characteristics that divergent thinkers would demonstrate: “fluency (the ability to rapidly produce a large number of ideas or solutions to a problem); flexibility (the capacity to consider a variety of approaches to a problem simultaneously); originality (the tendency to produce ideas different from those of most other people); and elaboration (the ability to think through the details of an idea and carry it out).”³

Divergent thinking, then, is a component of creativity that is necessary to a thriving design process since it is through divergent thinking that idea generation most often happens. Although divergent thinking is vital, especially in design culture, it is at times less recognized or valued than other types (linear, cognitive) of thinking among general populations. Conventional educational practices often reinforce linear thinking at the expense of divergent views, and traditional intelligence measures may not test for this type of thinking at all. Students who are naturally predisposed to divergent thinking processes may find themselves, therefore, forced into more conventional thought processes, specializing in single subjects without the “cross-pollination” of ideas that divergent thinking may provide.⁴

[previous page] *Students view their final work in an arrangement similar to a Parisian courtyard development, recalling the environments in which modern painting originated. Photo by Lohren Deeg.*

The value of divergent thinking in creative problem solving, and the influence that diverse experiences, ideas, and areas of study have in developing divergent thinking, has not gone unnoticed, however. Recently, *New York Times* columnist Thomas Friedman referenced the interrelated effects these processes have on creativity:

*“And where does divergent thinking come from? It comes from being exposed to divergent ideas and cultures and people and intellectual disciplines. As Marc Tucker, the president of the National Center on Education and the Economy, once put it to me: ‘One thing we know about creativity is that it typically occurs when people who have mastered two or more quite different fields use the framework in one to think afresh about the other. Intuitively, you know this is true. Leonardo da Vinci was a great artist, scientist and inventor, and each specialty nourished the other. He was a great lateral thinker. But if you spend your whole life in one silo, you will never have either the knowledge or mental agility to do the synthesis, connect the dots, which is usually where the next great breakthrough is found.’”*⁵

For designers, fluency, flexibility, originality, and elaboration are not the only elements necessary for creative thinking within the design process. Of equal importance is the ability to progress from a multitude of viable options into a single, well developed design solution with a strong rationale for its appropriateness. Convergent thinking is a complementary process to divergent thinking that allows this appropriate and well-conceived design idea to develop from the multiple possibilities. Convergent thinking has two elements: judgment, the evaluation of concepts to determine the ideas or components of ideas that contain the most potential; and amalgamation, the ability to combine the convergent ideas into a design solution that becomes more than simply the sum of its parts.

*“I like the way Newsweek described it in a recent essay on creativity: ‘To be creative requires divergent thinking (generating many unique ideas) and then convergent thinking (combining those ideas into the best result).’”*⁶

Divergent thinking and its creative counterpart, convergent thinking, involve engaging the entire brain in the process of creative problem solving, rather than relying solely on the characteristics or processes associated with either “right brain” (intuitive, holistic, and subjective) or “left brain” (logical, sequential, and analytic) thinking.⁷ For designers, the design process must seek input and methods that stimulate the cooperative functioning of both thought “types”.

If the practice of these different types of learning is valuable in shaping creative response to design projects, then one of the goals of design education should be to introduce students to these processes and equip students to use them in creating design solutions. Through repetition, skills in divergent thinking, creativity, judgment, and convergent thinking may be learned, refined, and

incorporated into a student's set of professional skills. The need to introduce students to these skills led the authors of this paper to investigate teaching methods that pushed students to use divergent thinking as a means to energize and inform a typical design process during studio hours and that desired an outcome and a product within the course of a single studio session. The outcome of the day's work could then quickly become a tool for convergent thinking processes, as students began to evaluate these solutions and incorporate them into refined concepts. This process of divergent/ convergent structure also had the ability to generate additional discussion and launch the student into further self-guided discovery.

This design methodology began as a series of "charrettes" – borrowing from the interactive and public participation exercises that are used to generate and exhibit ideas quickly. In the studio, a whole afternoon "in class charrette" was not intended to replace a student's own self-discovery, rather, it allowed an indecisive, unmotivated, or struggling student to commit to ideas quickly, and react to those decisions in a structured chain of events. The exercise encouraged the student to return to self-discovery immediately thereafter, even if their charrette product was less than successful.

The charrette process involves the rapid and interactive crafting of small study models or sketch models, and the trading of subject matter between students as a way to generate many design concepts that can then be evaluated, developed or rejected, and evolve as students test constructed prototypes. Descriptions of these exercises, and well as student testimony following these exercises, will constitute the body of this paper.

It is hoped that infused energy such as the exercises described here will generate new interest and new methods within studio based education, allowing it to continue evolving and responding to the ever-changing needs and sometimes distracted attention of the twenty-first century beginning design student.

"To be creative requires divergent thinking (generating many unique ideas) and then convergent thinking (combining those ideas into the best result)."

CONTEXT

Prepared 'Unit Guidelines' contained in the curriculum documents for the host curriculum program studied in this paper encourage the development and delivery for teaching methods, and even cite examples of previously used methods and exercises, but do not prescribe them completely, neither in the syllabus nor the project statements. Academic freedom is highly valued even in a team-taught situation, and instructors from a variety of design based education backgrounds bring their methods into the framework of each agreed studio project in the curriculum. The syllabus for this course offering states:

*"(The) course provides basic tools, techniques and processes for creative approaches to environmental design. The design studio will begin with exercises dealing with ordering principles and design analysis in two dimensions. These will involve fundamentals of proportion, scale, geometry, figure/ground, rhythm, hierarchy, and other visual and spatial ideas. These ideas also apply to three-dimensional work introduced in the following projects. The over-all focus is learning a common vocabulary and knowledge base, and understanding the design process. You'll develop the ability to see the world in different ways, think critically, and investigate alternatives."*⁸

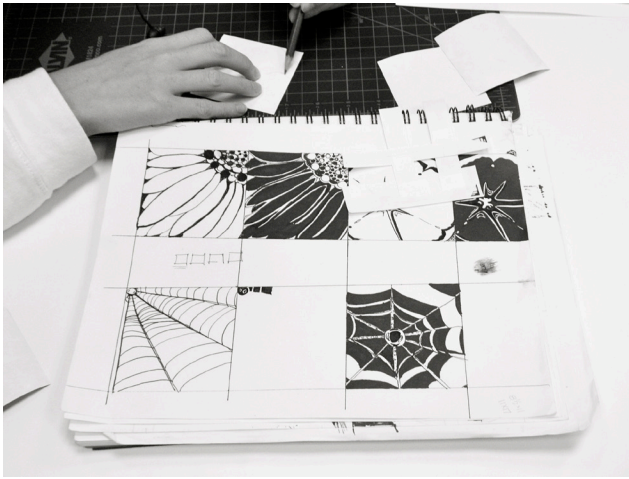
TWO DIMENSIONAL COLLABORATION

The exercise begins with a long established two-dimensional project exploring the concepts of abstraction and positive-negative composition. Students select small photographs of representations of the ordering and organizing systems and develop 'flash cards' to practice presentation layout and hand lettering. Students then choose several cards to begin abstracting these images into simplified positive and negative designs in the sketchbook and with tracing paper.

Students narrow down several choices of these created abstraction designs to make three inch by three inch 'tiles,' make reverse copies of these, and begin to explore the ordering and organizing systems again with the arrangements of the tiles.

This project or variations of this project have been a fixture of two dimensional design projects for many years, inspired by Wucius Wong.

When the students produce (through photocopy) four copies of each tile, they now have the beginnings of a collaborative opportunity. By simply trading studio desks, rotating positions in the studio like volleyball players rotating around a court, students can react and design arrangements of tiles with a complete 'fresh eye' approach by exploring another student's tiles. Students learn and discuss the results with each other between each rotation.



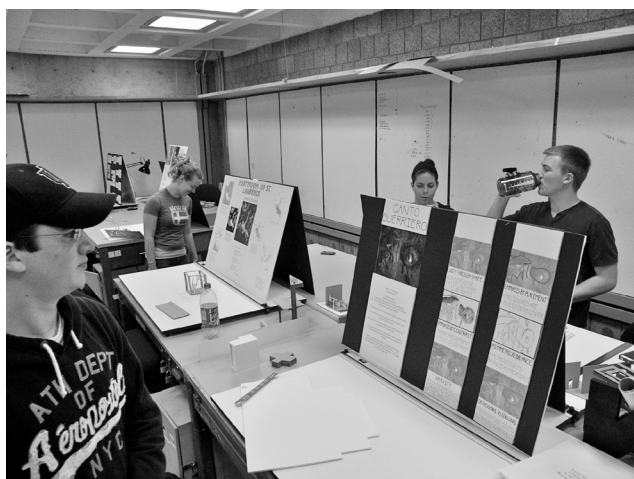
[top left] Figure 1: Students pull examples of ordering and organizing systems from the built and natural environment and begin abstracting these in the sketchbook. Photo by Lohren Deeg.

[top right] Figure 2: Students trade a collection of abstract 'tiles' and investigate different patterns with a 'fresh eye' approach to each other's work. Photo by Lohren Deeg.

[bottom left and right] Figures 3 and 4: The results of the collaborative process lead to richer final projects to discuss at the final review. Photos by Lohren Deeg.

Typically four to five rotations of twenty minutes each occur during the studio session. Through verbal instructions, the studio instructor requires that students explore different and less 'popular' (or understood) ordering and organizing systems. By the end of the studio session, a greater understanding of the potential of the individual tiles as well as several representations of the ordering and organizing systems have been discussed and explored.

This rotation through ideas and options reinforces divergent and convergent thought processes, and forces students to explore and reject several design options within the charrette. It was observed that students who undergo these collaborative processes rarely tend to go back to their original, 'first' thought or idea. Final projects are thus informed by the in-class collaborative 'charrette' paced activity.



[top left] *Figure 5: Following a literature review and visual analysis of a given painting, students prepare their 'analysis boards' and studio workspaces for a collaborative activity. Photo by Lohren Deeg.*

[top right and bottom] *Figures 6 and 7: Students build study models based on a 'fresh eye' interpretation of a classmate's assigned painting. A compressed timeline and an unfamiliarity with the painting reveal multiple and new approaches to the precedent. Photos by Lohren Deeg.*

THREE-DIMENSIONAL COLLABORATION

The translation of a painting into three-dimensional space is by no means a new idea. The connections between the composition of paintings and sculpted space goes well back to the de Stijl movement and is well established in the portfolio of le Corbusier and Aldo Galli. The presence of a beginning design studio project that ties a two dimensional painting to the definition of three-dimensional space thus accomplishes many objectives for developing critical thinking skills and design fundamentals.

“There was a strong dependence of much early modern architecture on painting. Cubism, Constructivism, De Stijl and Purism were all instrumental in the creation of the various currents of modern architecture. Many of the architects were also painters or had close friendships with painters.”⁹

The project begins with each student being assigned a painting; students must produce a critical essay on the painting, painter, and movement, and an analysis board that incorporates several ‘over-lay’ hand drawn diagrams. The ‘over-lay’ sketch quality diagrams isolate compositional elements from one another, and allow the student to understand and appreciate these elements isolated from the whole.

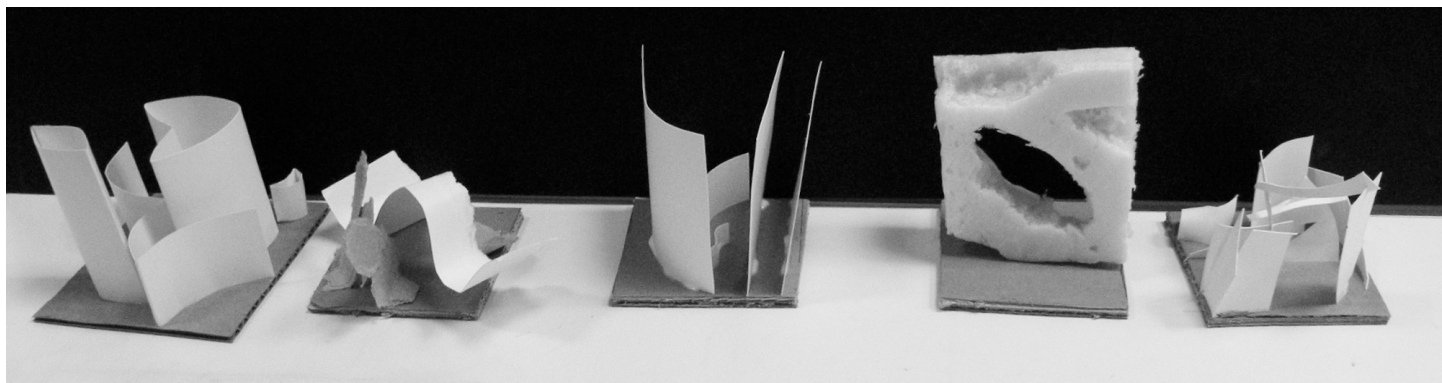
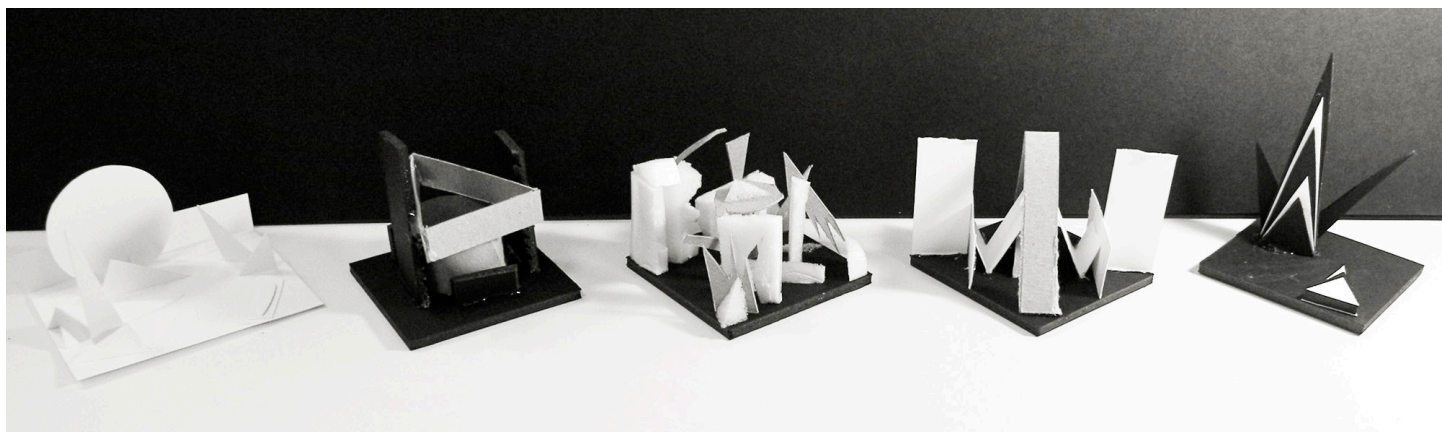
Following the completion of the analysis board, and a small three-dimensional study model (model zero), students are asked to display their boards at their studio desk location. Model materials and tools are readied. Students cut out four small model ‘bases’ and number them from one to four. Students then trade desks, and are encouraged to look at their classmate’s boards carefully. Students then begin to build a small (3” x 3” x 3”) study model using the materials, tools, and *based on the painting and diagrams located at their classmate’s desk, not their own assigned painting.*

Three rotations follow. Material and method variations in the design and construction of these small study models are intended to create variations in the responses. Instructors quick responses based on these imposed conditions as well as the allotted time (between twenty and twenty-five minutes). The process below defines the design and construction of the following study models.

Model Zero (Self): Completed before class. Students typically take an additive approach to this model, with typically one material.

Model One (Peer 1): Additive, using a variety of found / recycled materials.

Model Two (Peer 2): Subtractive, using packing foam reclaimed from shipping boxes.



Model Three (Peer 3): Using only scraps from previous two models, 'no cutting.'

Model Four (Self): Again, same as above, but working back at own workspace.

As the process illustrates, the student ends the studio session with five models, beginning and ending with their own work, but infused by three classmate's interpretations of their assigned painting, and also infused by time limits and materials and method restrictions.

The ability to react and evaluate the interpretations between each round allowed the individual student to be critical and develop an extended thought process towards their own assigned painting. Several students remarked in between rotations that they felt that their classmates were being too 'literal' or 'physical' in the interpretations of the paintings given the short time line. This motivated individual students to seek deeper and more meaningful interpretations of their assigned painting and stray away from a mere physical or spatial representation of the painting.

At the end of the rotations, the students are given the opportunity to see and review all of the study models en masse. The sheer amount of work generated within the context of one studio session is important to make

"The process from start to finish was like writing an essay. Not only did it open new ideas, it evolved the original idea as each model got better or utilized a more advanced approach."

[left] Figures 8 and 9: Examples of the collection of five study models produced within the context of the described exercise.
Photos by Lohren Deeg.

[below] Figure 10: A student reacts to a study model that a classmate has built during a twenty-minute rotation. Critical thinking skills are encouraged to develop throughout the process.
Photo by Lohren Deeg.

connections with the fluency values of divergent thinking and understand the scale of the activity which is analogous to processes of 'free writing' nature as described in the introduction of this paper. Students react to each other's work critically and can react to the models in relationship to each other, not just in relationship to the paintings that they interpret.

Over the course of the session, the students have not only learned a great deal about each other, but have gained each other's gratitude for the creative work done in exchange, and most valuably, furthered their thinking about their own individual project. One student wrote in reaction to the exercises the following, noting that the process included their own work at the beginning and end, like the format of the traditional essay:

*"The process from start to finish was like writing an essay. Not only did it open new ideas, it evolved the original idea as each model got better or utilized a more advanced approach."*¹⁰





Another student agrees and elaborates on this further:

*"I feel that this process (was) very beneficial. We (were) able to see our classmates' projects and bounce ideas off one another. I enjoyed seeing and experiencing how others reacted to my (assigned) painting and design (response). This provided thoughts and ideas from a whole new perspective."*¹¹

Yet another student remarked on the materials and methods restrictions introduced in models two and three, as described previously:

*"It helped to break away from the materials we were using. I specifically used only one type of material with my first model, but this process helped show what other materials are capable of producing. My last model (consisted) of four different materials."*¹²

Of particular interest to the authors is that the process revealed its limits, and did not satisfy every student's expectations for one's self or their classmates. One student was especially critical of his classmate's contributions over the course of the studio session:

*"I liked this process but I don't feel (that my classmates tried) as hard to create models for other people. If we had an incentive to create the best models then I think we would try harder."*¹³

However, the cumulative effect for most participants is well summarized in the following:

*"Not only did seeing what others did (with my assigned painting) help, but also, working with other projects was beneficial. It helped me step away from my project and helped tune my reaction-to-action process. My immediate thoughts started to be better reflected by my design models."*¹⁴





RESULTS AS OBSERVED IN STUDENTS' FINAL DESIGN PRODUCTS

It is intended, hoped and hypothesized by the authors that the results of the divergent thinking process described here will lead beginning design students to a richer, more meaningful, and diverse project, while containing and responding to the consistent values of space definition, entry, path, and threshold, an imagination of human scale, and craft. The continuous viewing of student projects in different contexts in relationship to one another also furthers this critical thinking.

[previous page and above] *Figures 11 and 12: Students review each other's work in a separate room and engage the models in relationship to craft, material, and interest. Photos by Lohren Deeg.*

[right] *Figure 13: Students view their final work in an arrangement similar to a Parisian courtyard development, recalling the environments in which modern painting originated. Photos by Lohren Deeg.*

Equally valuable to this divergent thinking process is its corresponding convergent process: based on the models designed in class and the students' analysis of the original painting, students must use judgment to evaluate the products and to modify, include, or reject design ideas in their next iteration of study models (6" x 6" x 6") leading to a refined, final project.



It may be difficult or impossible to determine the exact results of a divergent process without comparing student projects to one another. Critiques across studio sections (approximately eighteen students each, ranging from sixty to one hundred pupils per admission class) give all students opportunities to view each other's work and continue critical thinking skills in the process of evaluation and reflection.

Students have rarely been shy to share the observations that other studios and instructors take different approaches to a project like this, and this enriches the diversity of teaching and dialogue across studio sections, even if it frustrates those who subscribe to more linear thinking.

The four stage project, beginning with a rigorous essay and literature review, a careful diagramming exercise and visual analysis, abstracting or 'drawing out' layers of information gives students an abundance of visual material and background information to generate a number of ideas of interpretation and meaning. Students have sometimes remarked that there might be 'too much' information to sift through, but is usually satisfied quickly by the visual, spatial, and form vocabularies that they wish to explore through sheer preference via the assigned painting.

Past students have expressed great enthusiasm in visiting their assigned painting in subsequent years of the curriculum, often on University sponsored field studies. Students have found the precedents hanging in museums located in New York, NY, Washington D.C., Cincinnati, OH, and Kansas City, MO well into the third and fourth year of the undergraduate program. Most recently, paintings chosen at the host University's own museum of art allowed a more personal experience of exploration with particular regard to the physical scale, textures, and presence of the assigned painting. In most cases, the authors have observed that the learning associated with the painting becomes an intensely personal experience for a beginning design student, and a notable portion of the first year cumulative portfolio, speaking to the strengths of the project's learning outcomes.

To make a project whose genesis is from the roots of modernist design thinking in contemporary times is challenging. To translate paintings ranging from the Baroque period to Expressionist from two-dimensional to three-dimensional form is also a difficult task. However, the methodology of the project as described here allows students opportunities to engage with critical thinking, analysis, reflection, collaboration, and evaluation, and is one that has proven to give skills relevant to an emerging

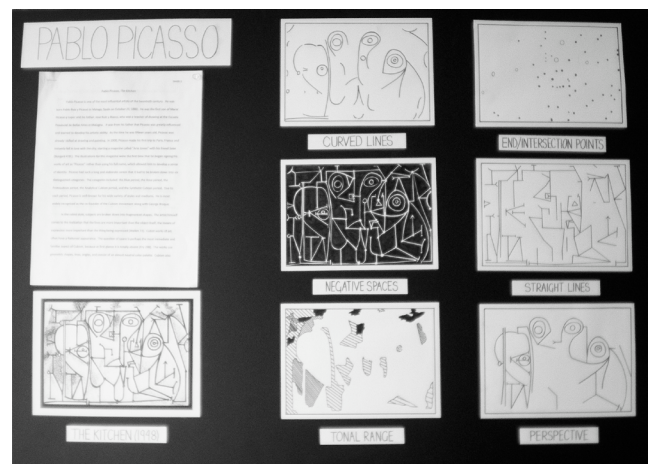
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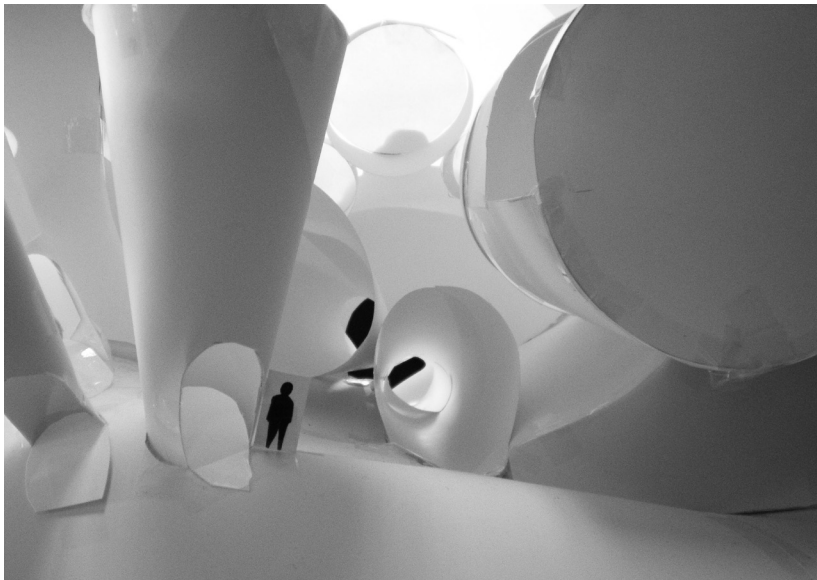
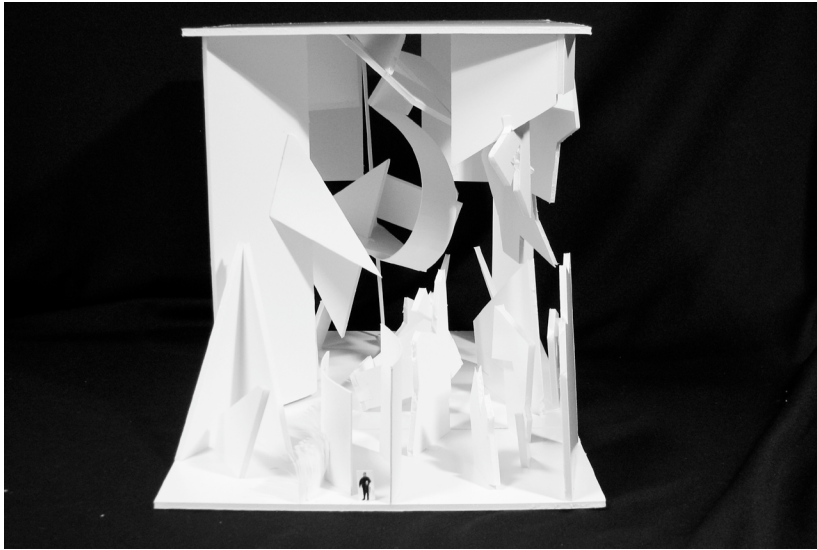
[top left] *Figure 14: Students view their final work in an arrangement similar to a Parisian courtyard development, recalling the environments in which modern painting originated. Photo by Lohren Deeg.*

[bottom left] *Figure 15: An example of an 'analysis' board, containing literature review and several 'over-lay' analysis diagrams focusing on vocabularies interpreted from the assigned painting. Photo by Lohren Deeg.*



design professional that last well into future projects in several professions in environmental design. We hope that this design process reinforces the fluency, flexibility, originality and elaboration described by Guilford as components of creativity and that students will assimilate some portion of these creative ideas into their individual design processes in their future academic and professional lives.





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- ¹⁰Huy Pham, Personal message to author, October 21st, 2011.
- ¹¹Austin Zehr, Personal message to author, October 21st, 2011.
- ¹²Leana Greene, Personal message to author, October 21st, 2011.
- ¹³Kyle Nallenweg, Personal message to author, October 21st, 2011.
- ¹⁴Casey Byrnes, Personal message to author, October 21st, 2011.

[right] *Figures 16, 17, 18, and 19. Examples of the final submission models, constructed entirely of color-less, translucent and transparent materials in an exploration of space, form, scale, and light, and occupying a cubic foot of volume. Each of these examples pictured originated from 20th Century 'Cubist' and modernist precedents.*



Delaminating the Roof

By David Karle, Assistant Professor
University of Nebraska-Lincoln, Architecture



Is the roof only a cover? Traditionally the roof has been ignored because from the traditional street level point of view it was invisible to the observer. The roof which really should be considered the fifth facade remains unacknowledged.¹

Currently, within the United States roof typologies are stagnant; pitched roofs for residential buildings and flat roofs for commercial buildings dominate the built environment. However, the roof has great significance throughout history. The Florence Cathedral, Filippo Brunelleschi; Sydney Opera House, Jørn Utzon; and the Yokohama Terminal, FOA; are all significant cultural and technological building constructs. These examples use “the roof as an archetypal and generative motif of built space and form.”² The roof is the last line of defense from the weather, but if delaminated can a roof serve more than one function? Can a roof be integral to the design and space rather than an after thought?

In the 18th century, the pitched roof had an environmental function. It was built-up with thick, heavy material and pitched to shed rain and snow. The attic space was once used as storage, then as servant quarters. After the roof was insulated and the attic space was comfortable, it became desirable space. This added an economic element to the roof. *Should we revisit the layering of a single building material?*

In the 19th century, the long span light-roof emerged as the driving form and construction typology referencing the era of factories, train stations, and market halls. These building typologies coupled with the long span roof made a combination of lightness, thinness, and porosity possible. *How can the spatial drivers of lightness, thinness, and porosity be reintroduced in today's built environment?*

The flat roof, as expressed by Le Corbusier's 1914 Domino House, had a formal function that allowed for flexible distribution of structure, walls, facade, and roof. The Domino House was the Model-T of houses, envisioned for mass production and uniformity. But should a house and a roof be mass-produced similar to the Ford Motor Company Assembly line? The standardization of houses and roof typologies can be arguably traced back to the standardization methods throughout American history, from the Jeffersonian grid and lumber sizes to 4'-0" x 8'-0" sheet material and Sears, Roebuck and Co. mail-order homes. These options traditionally simplify the roof and constructed it as an impenetrable datum and completely disregard its relationship to the interior. *Should the historic standardization and efficiency of the roof be re-tooled and refocused?*

Provided this brief history of roofs, it is ironic that today the most common function of flat roofs has been passive storage of mechanical units. The horizontal datum provides a continuous barrier against moisture, but it is also a barrier against light and sectional space. With an increase in knowledge, and a nod towards environmental awareness, suburban malls and strip malls are reducing their dependence on air-conditioning. The scale of the suburban strip mall varies but the roof is greater than all

the micro-climates of the interior space. This condition also provides an interior which is free to self arrange over time without any or very little reference to the exterior.³

The flat roof of a single story suburban strip mall is under-utilized and under-performing. The strip mall roof is large and free to grow endlessly due to air-conditioning technologies. In “Junkspace,” Rem Koolhaas states, “Air conditioning has launched the endless building.”⁴

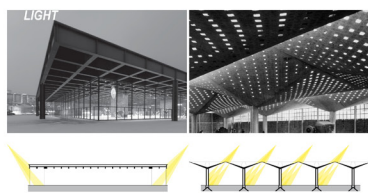
“If malls reduce their dependence on air-conditioning, two-thirds of which have been occupied by machinery, they can explore new forms and functions.”⁵ If liberated from air-conditioning machines, what other forms and functions could the roof provide? As architects and designers we need to re-examine this formerly forgotten territory in order to maximize function and habitation.

The flat roof of a suburban strip mall became the focus of investigation by a senior-level architectural design studio at The University of Nebraska-Lincoln, College of Architecture. The studio took on the challenge to study and propose a new roof for a 1970s suburban strip mall in Lincoln, Nebraska. The studio researched the implications of the roof’s vast scale that disconnects the interior from exterior. This out-of-sync interior-exterior relationship has produced two conditions: a blank exterior envelope, which has been studied by Farshid Moussavi, and the corollary interior environment that Rem Koolhaas has coined as “Junkspace”.

The project objectives used precedent case studies to introduce the students to built artifacts, scale/proportion, and materiality. It also provided base knowledge about roof typologies and investigated the embedded base-unit variables and descriptive geometry. The studio explored proposals to mediate the continuous datum that currently exists in the flat roof commercial typology. The studio was expected to continually learn, unlearn, and relearn the role of the roof in the suburban context. Students were asked to move beyond their preconceived notion of the *roof* and exploit the potentials that exist between the inside and outside when considering the roof as the fifth facade.

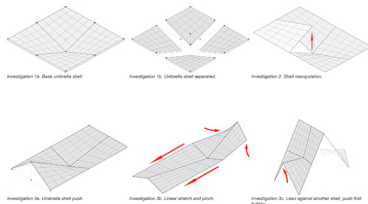
The design-research project was divided into three phases; structural taxonomy, descriptive geometry, and implementation. A three-phase process enabled students to research, comprehend, repeat, and implement a new design proposal for the existing suburban strip mall roof. The project investigated both technological and parametric relationships at all stages. The primary process identified structural logics, established variables within each typology, and augmented the components towards a new roof proposal.

How can the spatial drivers of lightness, thinness, and porosity be reintroduced in today’s built environment?



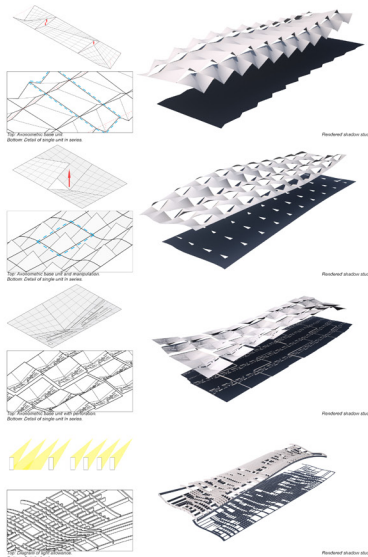
NEW NATIONAL GALLERY | HIGH LIFE TEXTILE FACTORY

Left: The New National Gallery in Berlin utilizes a Two-Way Frame in a structural manner that allows the structural supports to be positioned on the exterior. This allows for light to penetrate through the entirety of the gallery. Right: The High Life Textile Factory utilized a perforation and incorporates glass bricks in the Umbrella shell to allow light to create a dynamic diffused light condition.



VARIABLE DIAGRAM

The diagrams represent a series of manipulations to the control points, edges and faces of the roof typology



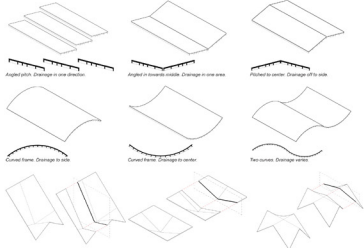
LIGHT DESIGN INVESTIGATION | UMBRELLA SHELL | TWO-WAY FRAME

The series of 4 design iterations involve simple manipulations to a base unit that is then populated along a surface.



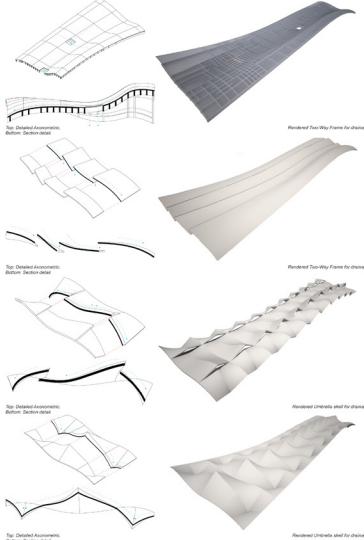
CHURCH OF OUR LADY OF THE MIRACULOUS MEDAL | NEW NATIONAL GALLERY

Left: The Church of Our Lady of the Miraculous Medal is structured off a manipulated Umbrella Shell form. The nature of the Umbrella shell allows for simple drainage. Water is able to drain from the top of the roof down to the bottom as the shell meets the ground. Right: The New National Gallery incorporates what is known as a flat roof. Drainage is directed to the edge of the structure.



VARIABLE DIAGRAM

This series of diagrams represents manipulations and arrangements to allow for water drainage.



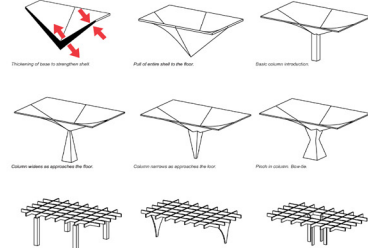
WATER DESIGN INVESTIGATION | UMBRELLA SHELL | TWO-WAY FRAME

Series of drainage and water analysis was done to further develop and understand previous manipulations



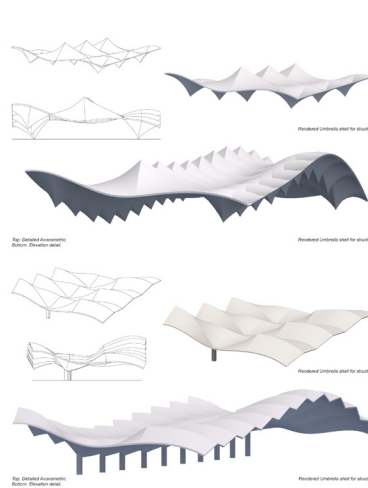
CHURCH OF OUR LADY OF THE MIRACULOUS MEDAL | NEW NATIONAL GALLERY

Left: The manipulated Umbrella Shell allows for the structure to be located in key points that support the entirety of the shell. This opportunity allows for a large structure to be built with minimal structural support. Right: The New National Gallery positions the structural elements on the exterior to create an open plan on the interior.



VARIABLE DIAGRAM

The final series of diagrams represent potential structural considerations for proper support of the roof types.



STRUCTURE DESIGN INVESTIGATION | UMBRELLA SHELL | TWO-WAY FRAME

The final series of design investigations involve analysis of structural members. They vary from basic supports to manipulations of the shell and frame to extend to the floor.

PHASE 1 - STRUCTURAL TAXONOMY

The studio used the structural taxonomy presented in Moussavi's *The Function of Form* as a starting point for the principles of structural roofing systems. Each student researched three of the following structural typologies to understand how a structural system performed through a series of logics and variables, at the scale of one bay or structural unit.

- 1 Grids and Frames
- 2 Vaults
- 3 Domes
- 4 Folded Plates
- 5 Shells

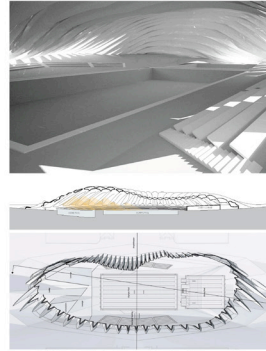
Once the student identified his/her structural logic(s), the relationships were identified and diagrammed in a series of precedents. A clear understanding and knowledge of typological variables became a foundation for exploration.

PHASE 2 - DESCRIPTIVE GEOMETRY

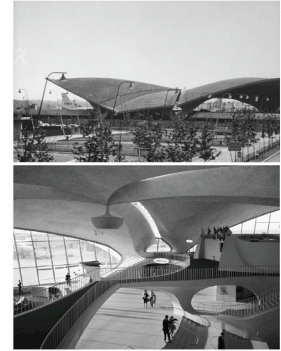
Descriptive geometry was used to graphically represent and communicate space in mathematical terms. The studio used *descriptive geometry* as a tool to further investigate opportunities within the roof typologies and structural constraints. Through this process objects, surfaces, and patterns were broken-down into base-units. Referencing again, *The Function of Form*, “In a transversal system, a “base unit” assembles a variety of causes and concerns into a complex supra-material whole - an amorphic rather than hylomorphic whole; this is, the way the elements combine is not subject to a predetermined system but is specific to those elements”.⁶ Understanding and breaking the roof typologies down into a series of smaller base-units provides the students with an inherent structural logic. It also forces the students to use the base-unit as a formal and spatial logic removed from preconceived notions.

The studio continued to develop their understanding of the roof typologies and began to rethink the ‘variables, parameters and rules’ found in the descriptive geometries under four lenses; light quality, water control, structure, and programmatic relationships. Physical models and drawings studied size, scale, proportion, and variable translation. Spaces and environments were created by expanding, tessellating, deforming, constructing and deconstructing the variables, parameters and rules.

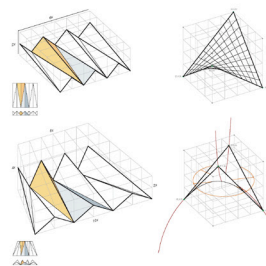
LIGHT



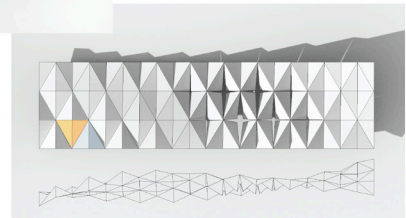
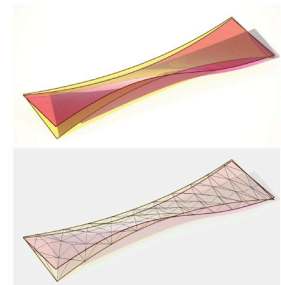
McCarren Park Aquatic Center (proposal), Form-ula, 2008
This unbuilt proposal for an aquatic center in Brooklyn combines an arch system and concrete folded plate system. Light shines in shafts through gaps between the plates.



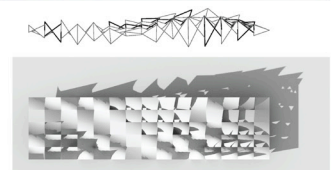
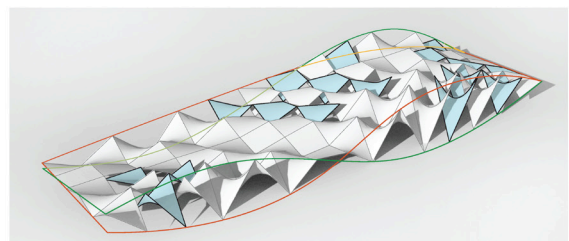
TWA Terminal, Eero Saarinen, 1962
Saarinen's terminal used massive, self-supporting thin concrete shells to bring in abundant light through the north and south “wings” as well as through gaps between each shell.



Generative diagrams
Both light schemes are generated from two intersecting surfaces, which will consider program and orientation on the actual site. The plates and hypars mediate between the two surfaces, creating tall volumes where they are further apart and more flat areas where they are close together.

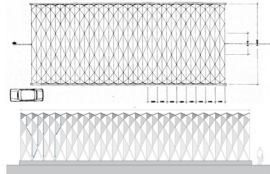


Folded plate
The diamond unit of the folded plate scheme can be split into four at its center and opened either upwards or downwards in varying degrees.



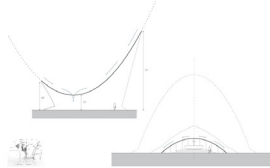
Hyper curved shell
By reversing the direction of some of the shells, light can be admitted in some areas while not in others.

WATER



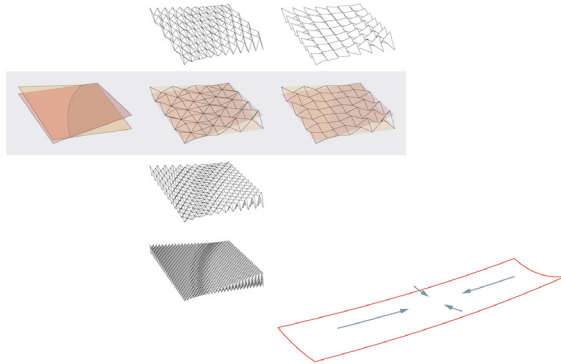
Mobile sulfur extraction factory, Renzo Piano, 1966

This mobile structure, open on both ends and at the dark triangles at the base, only partially screens the elements. The water runs down the channels in the folded diamonds to the ground.



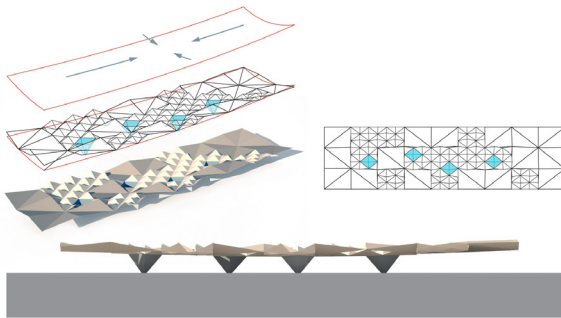
Chapel Lomas de Cuernavaca, Felix Candela, 1958

The chapel is a section of a single hyperbolic parabola ("hypar") in thin shell concrete. The water simply runs down the sides of the hyper and is collected at the base.



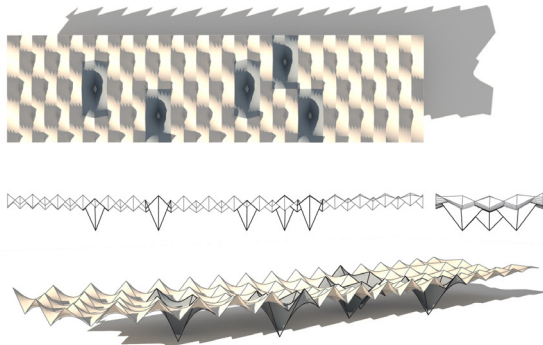
Generative diagrams

The water schemes differ from the light in two ways: the generative surfaces both slope towards the center and are arranged so that every diamond unit is convex.



Folded plate

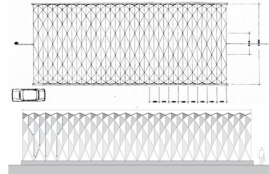
This folded plate scheme incorporates two different unit sizes. To accommodate water, some of the small interior units are inverted and brought down to ground level.



Hyper curved shell

The hyper water scheme only differs from the folded plate scheme in that it takes four hyper units to form a drain unit.

STRUCTURE



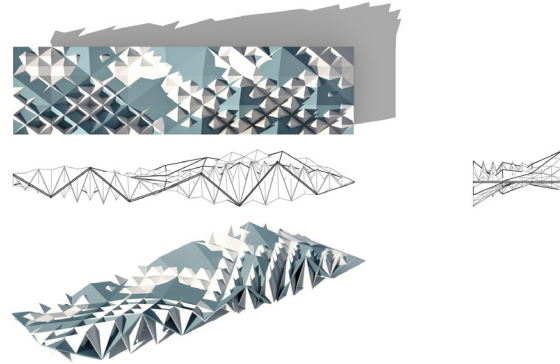
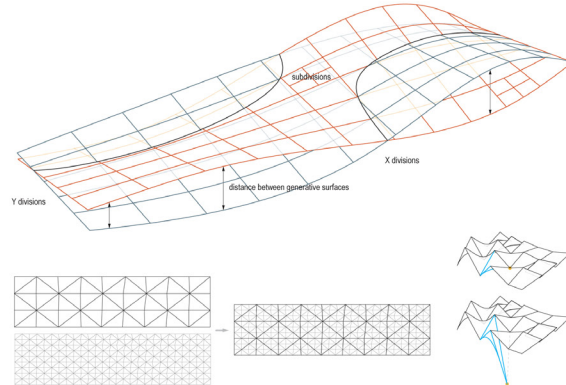
Mobile sulfur extraction factory, Renzo Piano, 1966

This mobile structure, open on both ends and at the dark triangles at the base, only partially screens the elements. The water runs down the channels in the folded diamonds to the ground.



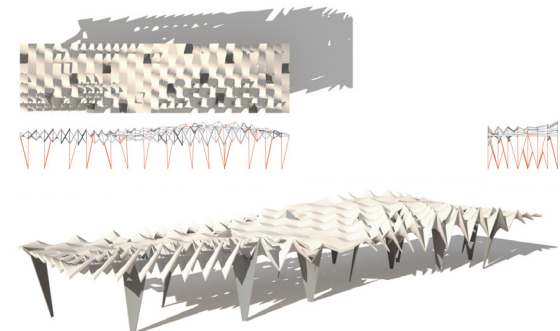
Philips Pavilion, Le Corbusier, 1958

The pavilion was composed of 9 pre-stressed concrete hyperbolic paraboloids, poured offsite.



Folded plate

Two overlaid folded plate systems, mediating between the same two generative surfaces, interlock and increase structural stability while providing interior volumes in the roof system and an additional layer of surface conditions.



Hyper curved shell

To create vertical members in the hyper system, one point from some of the four-point units is pulled down to the ground (see diagram mid-page right) without destroying the integrity of the hyper shape





PHASE 3 - IMPLEMENTATION

The studio investigated increasing the square-footage of a suburban strip mall roof in Lincoln, Nebraska by adding a second story of program on the roof as well as occupying vacant storefronts on the ground level. Revisiting the research conducted in Phase 1-Structural Taxonomy and Phase 2-Descriptive Geometry, the studio focused on the interior environment as a driver for the architectural potentials of the roof. By removing the existing strip mall roof construction; open-web joist spaced 6'-0" on-center with eight inches minimum of insulation, the occupiable space above and below the roof was reconsidered. The function and performance of the new roof supported and enhanced the spatial and programmatic relationships below.

During this phase the students were challenged to discover new programmatic typologies and functions for the roof. The studio leveraged the existing strip mall establishments along with their specific roof typology to propose a new program(s) for the roof. The studio sought to understand program not as determined by the client but an opportunity to re-imagine programmatic relationships and to resist the designer's propensity to unify, to order, to fix. Instead the studio sought to offer possible scenarios related to program. The studio re-calibrated the traditional notion of program through the lens of economies and untapped latent potentials within a strip mall. Borrowing from Banham's thinking in *The Four Ecologies* each student was responsible for siting four programs of four economies.

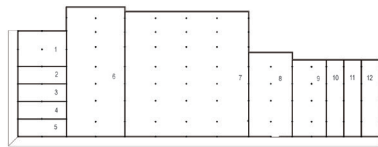
ARCHITECTURE OF FOUR ECONOMIES:

- 1 Production
- 2 Exchange
- 3 Distribution
- 4 Consumption

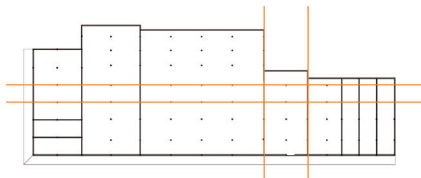
The economies: service, food, retail, and commercial are typical in a suburban strip mall complex. We often see a sushi restaurant next to a nail salon next to a greeting card shop. Each economy caters to a specific, yet generic set of cliental. The people who get their nails done also buy greeting cards and/or order sushi take out. The studio proposed a new set of spatial activators or stimulators for the site. The selection of these programs supported the traditional notion of the suburban strip mall by positioning like and dislike programs of varied economies. But can new economies serve a larger collective set of cliental? Can the relationships that exist between economies produce new forms of cultural exchange/production?



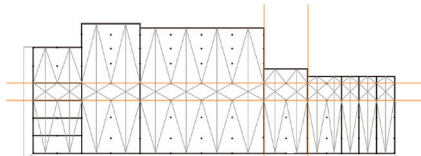
Existing Structure: Columns are laid in a grid pattern in order to support a lightweight roof load and allow for easy program change.



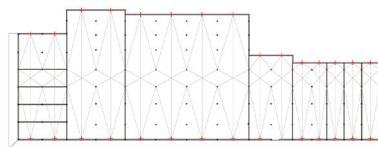
Program: 1. Rolling Back Restaurant, 2. Proposed Food Shop, 3. Office Suite, 4. Williams Classroom, 5. Hall Masters, 6. Waggoner, 7. Sunken, 8. Varsity, 9. Varsity, 10. Area Card, 11. El Toro Restaurant, 12. Varsity.



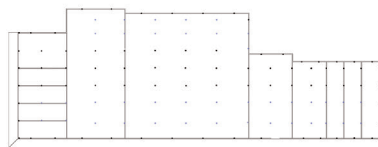
Establishing a Core: A structural core is determined by mapping out access points onto the roof. Access points are located in existing voidances in order to respect existing program space.



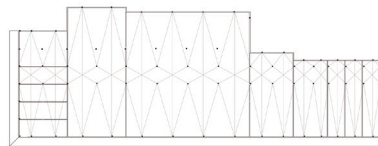
Setting up the System: A hybrid plate system is established to maintain column-free space below while providing appropriate slope ratios for forming and setting. Heavier planting is done in the structural core, lighter planting is done midway between the core and the perimeter, and the lightest planting is done towards the perimeter, where the concrete shell is at its weakest.



Structural Integrity: Proposed columns are placed based on points where loads would be too great to be supported by existing columns. A cast-in-place concrete shell system is proposed in order to transfer heavy loads without the use of steel beams.



Eliminating the Clutter: The proposed columns support vertical loads enough to allow the removal of unnecessary existing columns, therefore providing more column-free space to the programs below.



Conclusion: The final proposed structural system.

Center: Varies

Silicone Seal
Bolt Fixing
Connector Plate
Structural Steel Support
Bracing

Center: Varies

1/2" Polycarbonate
1" Airspace
Structural Steel Support
Bolt Fixing

EL: 117'-0"

Soil
Area Drain
Smooth Gravel
Drainage Membrane and Root Barrier
8" Thermal Insulation
Vapour Barrier
Cast in Place Concrete
Rebar

Suspension Rod
Secure Clip
2' x 4' Panel
(Aluminum metal with acoustic lining)

Existing Grouted CMU
Proposed cast-in-place Concrete
Column

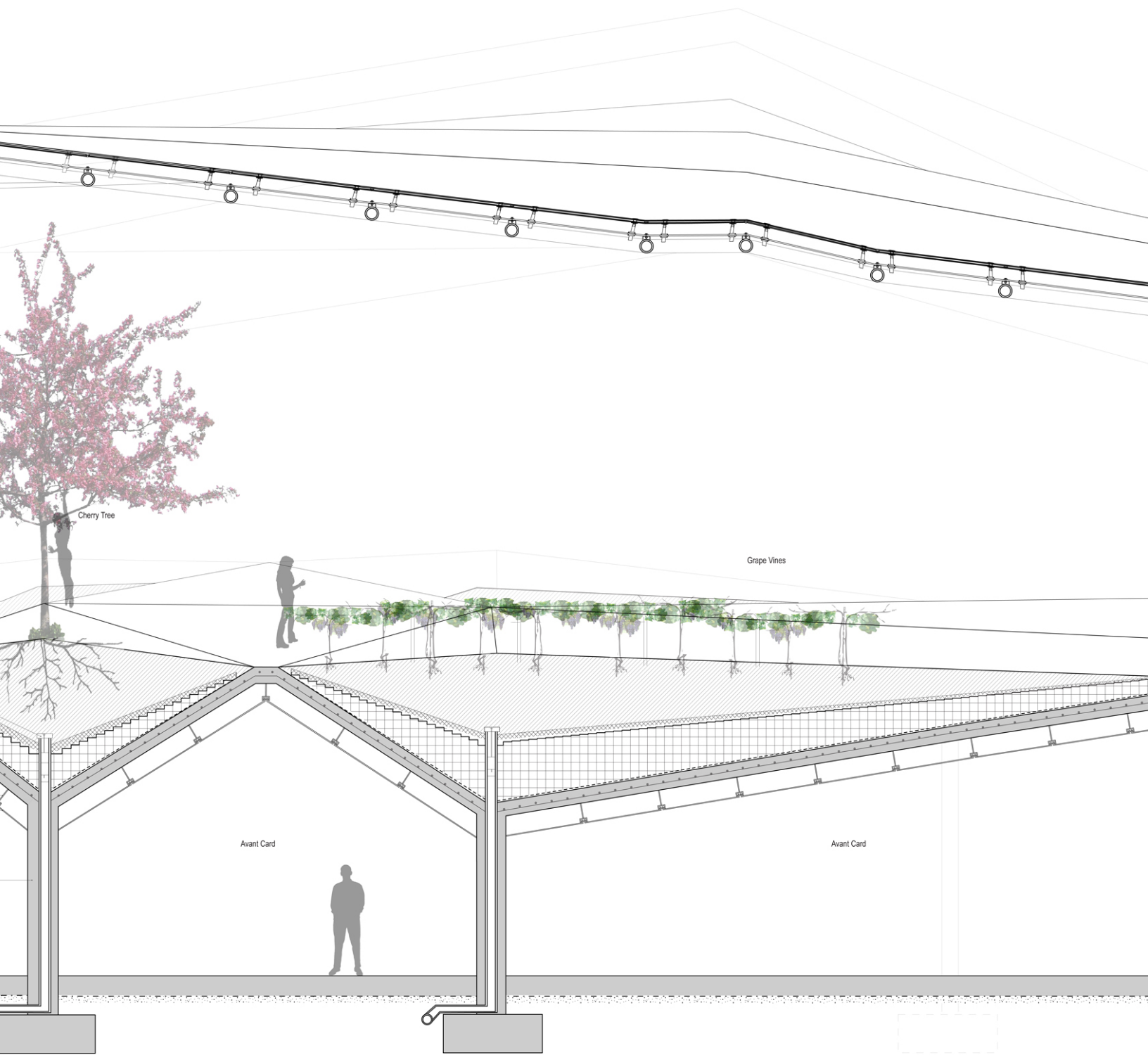
EL: 100'-0"

Concrete Slab on Grade
Thermal Break
Moisture Barrier
4" Gravel
Extruded Polystyrene foam insulation

Drainage Membrane
Drainage Mat
Subsoil Drainage
5' x 5' Footing

STUDIO OUTCOMES

Two projects that illustrate and argue for this type of architectural proposals are; Publishing House: Papermaker, Publisher, Author, Consumer by Drew Seyl and Community Garden: Mico-climate, Flower Shop by Amanda Mejstrik. Each proposal used the variables within a roof typology to maximize and exploit programmatic possibilities.



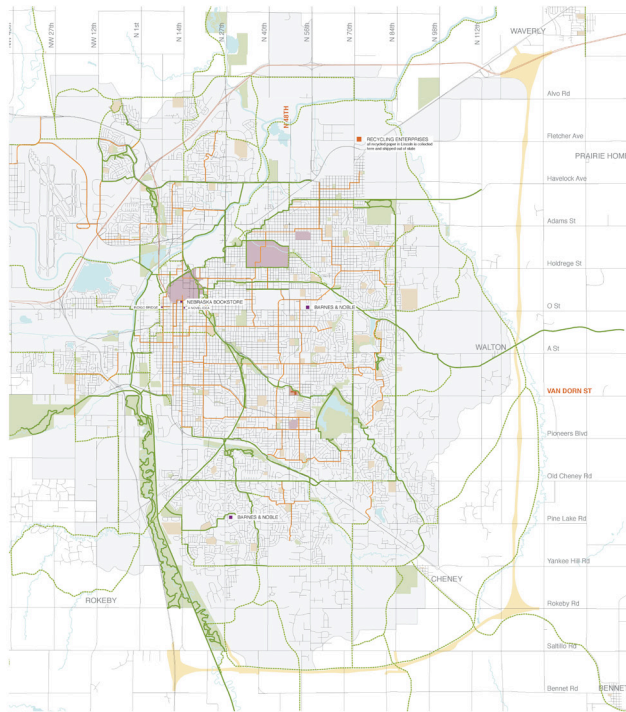
[previous page] *Phase 3 strip mall roofs and elevation.*
 [left] *Phase 3-Structural Diagram by Amanda Mejstrik.*
 [above] *Phase 3-Wall section by Amanda Mejstrik.*

The book is far from dead, but conventional big publishing is on its last legs. A successful modern publishing house is small, **adaptable**, and pushes the integration of paper and digital platforms.

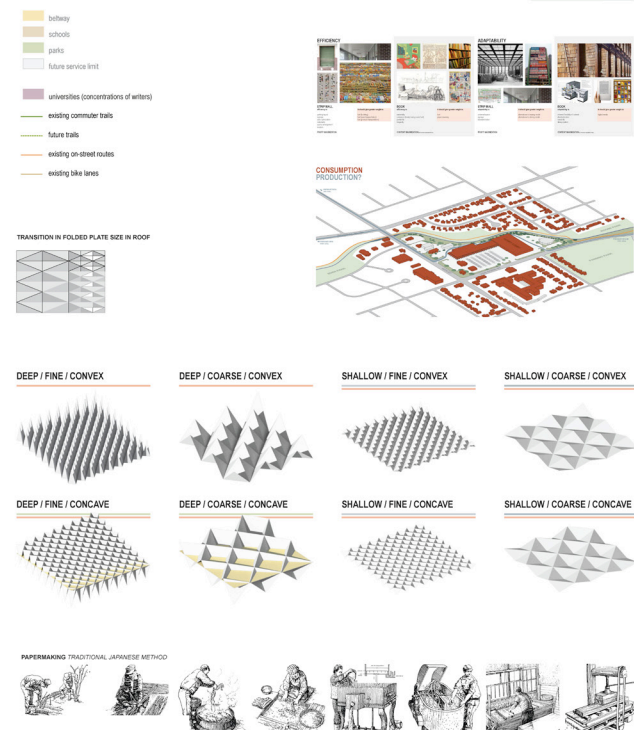
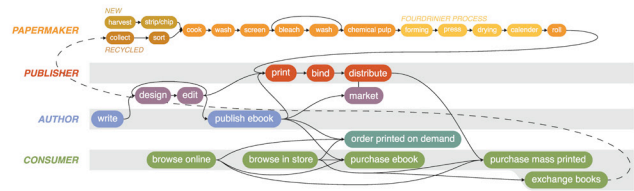
The book and the strip mall share essential qualities. Each are omnipresent, adaptable, and honed to maximum **efficiency**. Van Don Plaza, centrally located and the epitome of the generic strip mall in Lincoln, is well situated to become a hub for everything involved in the production and consumption of literature.

FOUR PRESCRIBED ECONOMIES:

CONSUMPTION EXCHANGE
PRODUCTION DISTRIBUTION

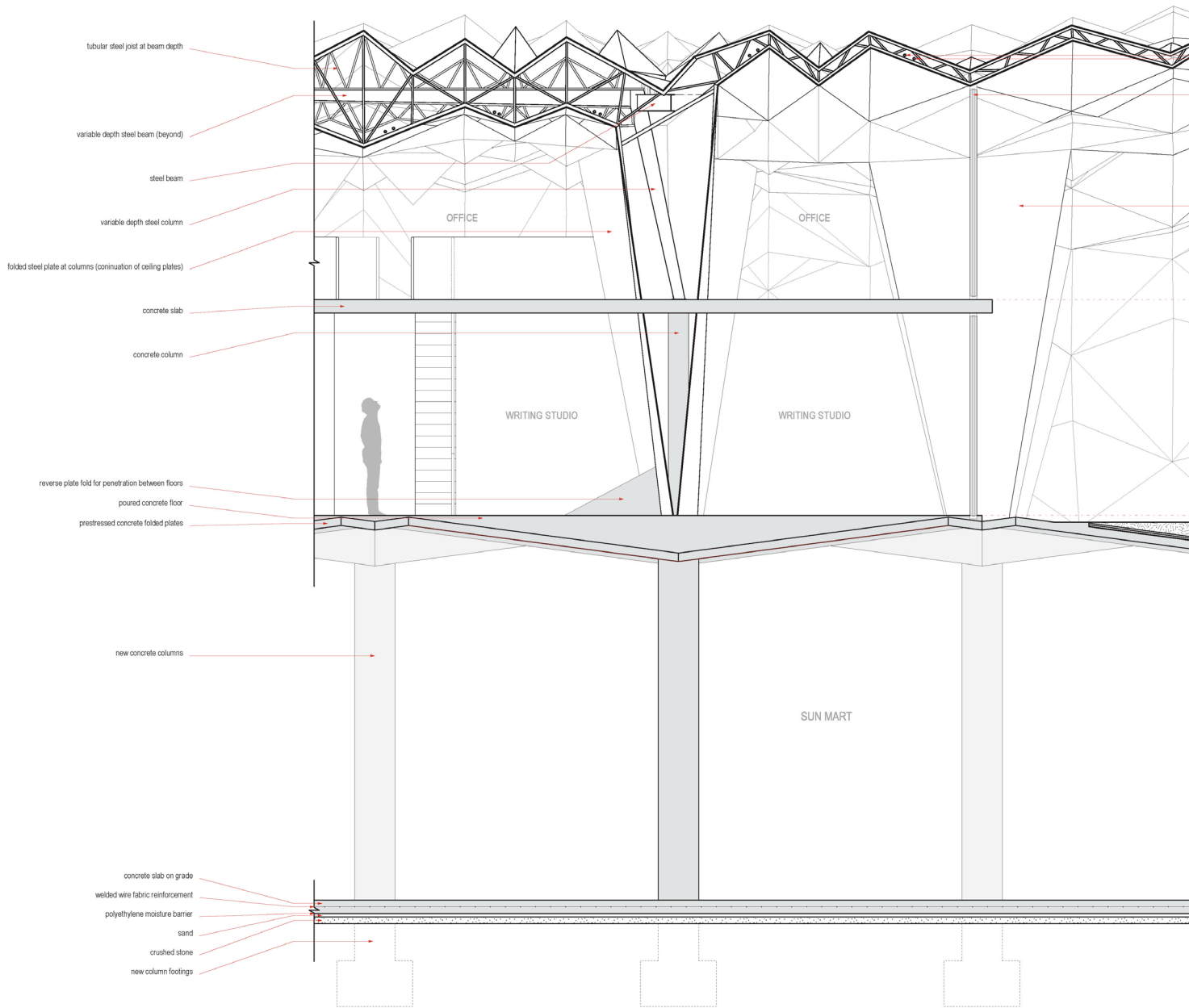


Diagrammatic elevation from south

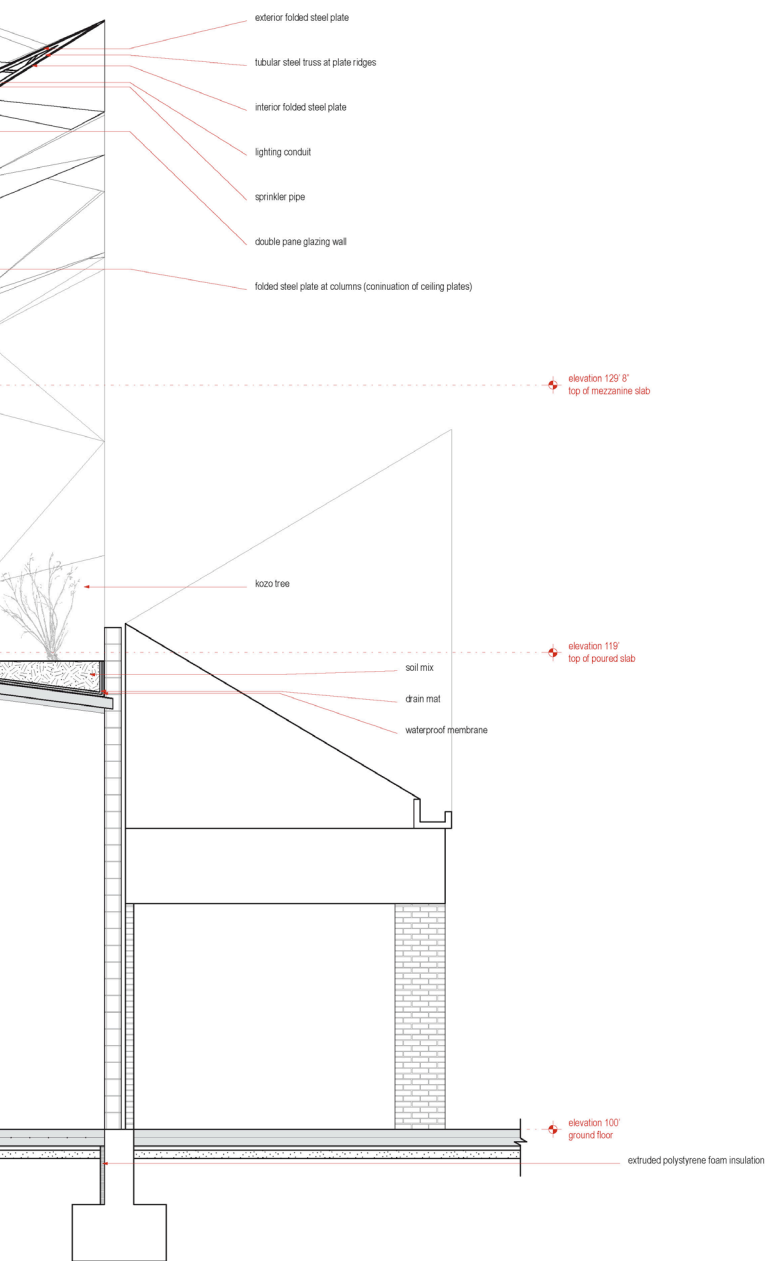


For example, the Folded Plate typology was researched and implemented in the Community Garden scheme. The design leveraged the sectional quality of the folded plate to establish a matrix of parameters and variables to facilitate: soil depth, plant spacing, moisture level, and drainage of both native and non-native produce. This taxonomy allowed for variable change to occur across the surface. The variable change of the folded plate aligns itself to the secondary structural grids. First with the concrete shell between the existing strip mall and the microclimate, second for the glass roof between the microclimates and exterior. This design augments the sectional space of both the existing strip mall and the new microclimates above. The Publishing House scheme utilized the folded plate and the hyperbolic curve to control light along with integrating the structure. This coupling of roof and structure through a continuous roof and column surface allowed for an organized yet varied surface. In both projects the floor-to-ceiling sectional relationship was augmented to maximize space, control light and integrate structure.

[right] Phase 3- Exploded axonometric by Drew Seyl
[above] Phase 3- Programmatic justification by Drew Seyl



This reinterpretation of the flat datum pushes back on Koolhaas's definition of *Junkspace* and repositions the roof as a spatial driver for suburban strip malls. No longer is the roof or the space beneath the roof subject to banality. Rather it is engaged in a new spatial and performative architecture. By conceptually delaminating the layers of the roof, the interior is exposed and corresponds with the exterior. This *delaminated* space provides opportunities for designers to re-conceptualize the role of the roof within the built environment.



¹ "Student Works: A roof is a Roof is a Roof" Jul 16, 2010, http://www.archinect.com/features/article.php?id=99880_0_23_0_M

² Andrea Deplazes. *Constructing Architecture, Materials Processes Structures.. Second Edition*. Pg. 236

³ The Design Studio at University of Nebraska is based on a studio ran at the Harvard Graduate School of Design by Farshid Moussavi, *The Function of Roofs: The Urban Mall*.

⁴ Rem Koolhaas, "Junkspace," *Obsolescence*, October, Vol. 100. (Spring, 2002): 175-190.

⁵ Harvard Graduate School of Design by Farshid Moussavi, *The Function of Roofs: The Urban Mall*.

⁶ Farshid Moussavi, *The Function of Form*. (New York: Actar D USA), 28-29.

Brian M. Kelly, RA

Brian M. Kelly, a licensed architect in the State of Nebraska, joined the UNL College of Architecture in the Fall of 2009. His previous teaching experience includes Drury University's Hammons School of Architecture in Springfield, MO and California Polytechnic State University at San Luis Obispo. Prior to joining the faculty at UNL, Brian served as lead designer in the office of Randy Brown Architects, designing several award-winning projects of various types and scales. In addition to teaching, he is a partner with AToM, a design office which focuses on smaller scale architectural projects, objects, and graphics.



Randall Teal

Randall Teal is an Assistant Professor of Architecture at the University of Idaho. His pedagogical and research interests are in design fundamentals and architectural theory with a significant influence from Continental thought. His writing focuses primarily on understanding and promoting situated dialogue between creative processes and the built environment.



Tim Hemsath, AIA, NCARB, LEED

Timothy Hemsath, is currently Assistant Professor in the College of Architecture. He has over 10 years of combined industry and educational experience in the design, construction and research in energy efficiency and sustainable design. He was the architect for the ZNETH and ZNETH II energy efficient prototypes working with the College of Engineering. He has served as the PI on a \$98,787 Nebraska Research Initiative funded project to build research capacity surrounding Zero-net energy research at the University of Nebraska. Currently, he serves on the UNL team, Building Energy Efficient Homes for America, composed of researchers funded by the U.S. Department of Energy's Building America Program working with home builders and national partners.



Sean M. Rotar, RLA, ASLA

Sean Rotar is Assistant Professor of Landscape Architecture at Purdue University in West Lafayette, Indiana, where he teaches introductory courses in landscape architecture, as well as design studio and implementation classes. Sean earned degrees in landscape architecture from Ball State University and the University of Illinois. He has practice experience in Illinois and Indiana and prior to his appointment at Purdue, Sean spent four years as instructor of landscape architecture at Ball State. A Past President of the Indiana Chapter of the American Society of Landscape Architects, Sean is involved in promoting the profession through service at the state and national levels. Sean's research interests include the history of designed and vernacular landscapes, and studio and classroom pedagogy in the scholarship of teaching and learning.



Lohren Ray Deeg, A.S.A.I.

Lohren Deeg is an Assistant Professor of Urban Planning at Ball State University in Muncie, Indiana, where he has taught in beginning design and communication courses since 2001, and currently serves as first year coordinator. Mr. Deeg is also a Ball State alumnus, having been involved with the university's community planning and urban design outreach program named 'Community Based Projects' since 1996, where he has assisted with over fifty community "charrette" workshops in several municipalities across the state, region, and in international contexts. Mr. Deeg collaborates with a multidisciplinary firm in downtown Muncie, Indiana, and maintains a small independent illustration practice as a member of the American Society of Architectural Illustrators.



David Karle

David Karle is an Assistant Professor in Architecture at the University of Nebraska-Lincoln where he teaches undergraduate courses in design studio and urbanism. David has also taught architecture courses at the University of Michigan. He has worked professionally throughout the United States, in Australia, and at Mack Scogin Merrill Elam Architects on the Yale Health Service Center Project. David has received national and international awards for his design work including: Green Lung: Toronto Canada and Digital Fog: Detroit, Michigan.



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